PETROLEUM DEVELOPMENT AND TECHNOLOGY

1943

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PETROLEUM DEVELOPMENT AND TECHNOLOGY
1943

PETROLEUM DIVISION

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COVERING THE YEAR 1942

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FOREWORD

The aim and ambition of this Division, its officers, committees, and members, during the present national emergency, is the successful conclusion of our war effort and of a lasting peace to follow. To that they have dedicated their services and, in many instances, their lives.

A large number of our most active men are not available to us during these strenuous times, and the work that they had been doing has been added to the duties of those with whom rests the responsibility for carrying on. The effectiveness of their service is well exemplified in this volume of Petroleum Development and Technology, which is commended to our members and to everyone interested in the petroleum industry and its place in our national welfare.

It is essential that this Division continue to function with ever increasing effectiveness, that scientific and technical research be continued, that a steadily augmented flow of petroleum and its products be available wherever needed for our armed forces, and that the members of our Division assume heavier and heavier responsibilities not only in their own regular sphere of activity and in furthering the war program, but also in training others to assist and, if necessary, replace them.

In partial fulfillment of such duties, and operating for the first full year under its new by-laws, the Division has added standing committees on geophysics, production geology, and education. The creation of and the functioning by such committees are already assisting materially in the advancement of the Division. Through them are assured essential data relating to geophysics and production geology as far as they pertain to the technology of producing oil and gas, and a steadily developing educational technique to meet the changing and expanding needs of the industry. Also in fulfillment of such duties, the Division has changed the time of its annual meeting from fall to spring, and technical meetings will therefore be held this year at Dallas, Texas, May 6 to 8, inclusive, and at Los Angeles, California, on October 21 and 22. Such change will space our technical meetings more uniformly throughout the year and assure a more regular flow of papers for publication. An outstanding program has been perfected for the Dallas meeting, one of equal merit is assured for the Los Angeles meeting, and plans are now being developed for the New York meeting in February 1944.

In addition to what has already been accomplished, plans for this year include some revision in the presentation of development and production reviews in the annual volume, a continuation of assembling engineering reports of typical oil and gas fields, and such other work as will best serve our nation, our industry, our Division, and our members.

The Division hereby expresses its deep appreciation of the whole-hearted cooperation it is accorded by the other members of the Institute and by the personnel of the Institute's New York headquarters. It also expresses its sincere thanks to the various committee chairmen, vice-chairmen, committee members, authors, and members of the Division that participate actively and effectively in the affairs of the Institute.

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In 1936 the Institute established the Anthony F. Lucas Gold Medal, to be awarded from time to time "for distinguished achievement in improving the technique and practice of finding and producing petroleum." These awards are sponsored by the Petroleum Division.

Captain Lucas was a pioneer in the oil industry, one of the early wildcatters and a leading mining and petroleum engineer. He was famous as the discoverer of Spindletop. He became a member of the Institute in 1895 and in 1913 was the first Chairman of the Petroleum and Gas Committee of the Institute, the forerunner of the present Petroleum Division. He also headed the Committee in 1914, 1917 and 1918.

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Chapter I. Production Engineering

An Engineering Study of the Magnolia Field in Arkansas

By H. F. Winham*

(New York Meeting, February 1942)

Abstract

The history, development, subsurface geology, production, economics and estimated reserves are discussed in this paper. The Magnolia structure is an anticline with a known maximum structural relief at 372 ft., and the areal extent of the producing acreage is 4494 acres. Production is obtained from the Smackover oölitic lime and 116 successful wells have been drilled. The field, which was developed on 40-acre spacing, has been under strict control. It is believed to be producing with a strong water drive. To date it has produced more than eighteen million barrels and the estimate of ultimate recovery is 220 million barrels.

Early History

The Magnolia field is in Columbia County, Arkansas, T. 17 S., R. 19 and 20 W. Various geologists had long been interested in this general area, and as early as 1921, John F. Magale was able to define a surface structure.

The first wildcat, one of the first in Columbia County, was drilled in 1923 by Mid-States Oil Co., in sec. 10, T. 17 S., R. 20 W. This well was about 1½ miles northwest of the Kerlyn Oil Company's discovery well and was based on surface geological work done by Jewel and Dobie. Subsequently, several shallow wells that were not carried below the Upper Cretaceous beds were drilled in the immediate area of the discovery well, but none of them contained any commercial showings of oil or gas. In the latter part of 1935, Elam and Magale (or Southwood) Garrett No. 1 was located in sec. 13, T. 17 S., R. 20 W., ¾ mile east of the discovery well. It was drilled to a total depth of 4018 ft. in the lowermost Glen Rose beds but failed to obtain any showings of oil or gas.

Interest had been stimulated in this general area, however, by the discovery of several oil fields, mainly Glen Rose oil production in the Rodessa field in Louisiana in 1935, Smackover lime production in Snow Hill in May 1936, production from the Cotton Valley formation in Schuler in 1937, and Smackover lime production from the Buckner field in November 1937. With this background and subsequent seismic work, which was carried on partly because the old shallow wells drilled in the township had shown evidence of closure in the Upper Cretaceous beds, the discovery well, Kerlyn Oil Company's Barnett No. 1, sec. 14, T. 17 S., R. 20 W., was originally projected to a total depth of 6300 ft., to test the equivalents of the Morgan sands of the Cotton Valley series, then producing at Schuler. The well was carried to a depth of 6325 ft. and tested the objective beds without finding commercial production.

In the meantime, however, one well had found production in the Jones sand and another in the Smackover lime at Schuler. Kerlyn immediately made arrangements to deepen the Barnett well to the Smackover lime. The top of the Smackover lime was encountered at 7618 ft. and the well

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* Production Department, Texas-Gulf Area, Shell Oil Co., White Castle, La.

was cored and drilled to a depth of 7740 ft. Showings of oil and gas were encountered in porous oölitic lime from 7647 to 7652 and from 7664 to 7669. After some difficulties in completing the well, some production was obtained during March 1938, and the well finally was completed on Apr. 2, 1938, producing 298 bbl. per day on a ¼-in. choke.

Further activity at Magnolia was held in abeyance until the completion of another Smackover lime test 6 miles to the east, which later proved to be the discovery well of the Village field. This well was completed June 26 1938, and added considerable stimulus to the development of the whole area. Three wells—Atlantic-Harrington No. 1, Atlantic-Baker No. 1 and Petroleum Finance-Baker No. 1—were all started in the latter part of July, located in a straight east-west line just north of the discovery well on 40-acre locations. Just prior to the starting of these wells, the Atlantic Refining Co. had acquired the Magnolia discovery well and all of the holdings of the Kerlyn Oil Co. Shortly thereafter, Grady Vaughn started his Nannie Garrett No. 1, a southeast offset location to the discovery well. All four of these wells were carried to the Smackover lime, but the first three were dry holes and only the fourth one was a good producer. The Vaughn well encountered the top of the Smackover lime 127 ft. higher than the discovery well, whereas the other three wells encountered the Smackover lime from 58 to 83 ft. lower. The northern productive limits of the field were immediately established and the structure was proved to be rising to the south. After this, orderly and uniform development, on 40-acre spacing, was continued in east, south and westerly directions.

Development

During the remainder of 1938, development in the Magnolia field was confined to immediate offsets to the two producers, with six wells producing at the end of the year. By that time the lease owners had sufficient justification to embark upon a drilling campaign, and development was stepped up considerably. At one time, 15 strings of tools were in operation in the field.

During July and August of 1939, the peak rate of development was attained, 12 wells being completed during July and 14 during August. For the most part, the development was limited to offset locations or stepping out only one location, but during June of 1939 a 3000-ft. outstep to the east and a 5000-ft. outstepping well to the west were drilled. Each of these wells encountered the top of the Smackover lime at points higher than generally expected and proved that the field was much larger than anticipated.

The development of the intervening territory was carried on at a rapid pace, and 87 wells were producing by the end of 1939. From this time onward, development slackened somewhat but by the end of January 1941 there were 17 operators in the field and 116 wells had been completed. The total number of wells drilled in the field, including dry holes, is 124.

It is notable that the eight dry holes drilled on the Magnolia structure are all very close to the productive limits of the field and consequently have served to establish these limits accurately.

The orderly and even development of the Magnolia field can be attributed to two factors, both of which were brought about through the control exercised by the Arkansas Oil and Gas Commission. As soon as the field was discovered, this body set up rules for development and prevailed upon the operators to adhere to them, which resulted in the 40-acre spacing of the field. This fact, in turn, caused each well to step out at least ¼ mile, which was a limiting factor on the prudent operators to await the time until development had approached their leases.

The Magnolia field was drilled, with but few exceptions, to the 40-acre spacing pattern, the wells being located in the approximate center of the drilling units. The few exceptions not drilled in the center of a 40-acre spacing were permitted by the Oil and Gas Commission only after open hearings at which all facts and requests were presented for consideration. This body is to be commended on its diligence in insisting that the operators adhere to the prescribed spacing scheme. The small tracts scattered throughout the producing area were unitized into 40-acre drilling units, thus permitting all owners of acreage in the producing area to recover an equitable share of the oil produced.

The rules of the Arkansas Oil and Gas Commission also provided that three strings of casing be set in all wells. These were required to be a surface string of not less than 100 ft.; an intermediate string, set in hard chalk at about 2200 ft.; and a producing string set on top of or through the producing horizon. Two different casing programs were utilized by the various operators: the larger called for a 16-in. surface casing, 10¾-in. chalk string and a 7-in. oil string and the smaller one utilized 13⅜-in. and 5½ or 6-in. casing. During the early stages of development the larger design was the more popular, but as soon as the reservoir characteristics had been adequately determined the smaller program was used in almost every case in the interest of economy.

As soon as rapid development commenced, it was apparent to those engaged in the supervision of drilling that accurate data must be secured as soon as possible concerning the gas-oil contact and the water-oil contact of the main producing reservoir. The great majority of the wells were cored from the top of the producing horizon to the limits of their penetration.

A gas cap was discovered as soon as development had progressed far enough up-structure to penetrate it. The gas-oil contact was determined by coring and drill-stem testing to be 7140 ft. subsea. This point has been confirmed by almost every well drilled through the gas cap into the main oil-saturated zone. Variations from this point will be discussed later under Subsurface.

The water-oil contact, however, remained rather obscure, owing to mechanical difficulties in the discovery well and, although originally reported at 7348 ft. subsea, considerable doubt was later thrown upon this figure because of a possible crooked hole and reported hole-depth corrections. It was not until May 1939 that the oil-water contact in the main body of the field was penetrated, drill-stem tested and the contact accurately determined to be 7318 ft. subsea. This point has been fairly well established throughout the field except for a small portion on the southwest flank, which also will be discussed under Subsurface.

With the establishment of the gas-oil contact and the water level, the completion of the wells became more or less routine. Wells were completed both by cementing casing through the gas-oil contact with open hole below or by drilling to total depth, setting casing on bottom and gun-perforating the producing intervals. Owing to the fact that the main oil column is approximately 180 ft. thick, with a gas cap having a maximum thickness of 120 ft. on the crest of the structure, some operators were reluctant to drill the wells close to the water level when they could secure good producing wells with shallower penetration. However, a considerable number of wells were drilled to a safe penetration (10 to 15 ft.) above the water-oil contact.

Cement jobs were successful in shutting off the gas from the gas cap and in only a few wells was it necessary to squeeze cement after they were brought into production in order to repair the shutoff because of high gas-oil ratio. The Oil and Gas Commission again displayed its strict control by testing each well upon completion, to determine that the gas-oil ratio was below the allowed limit of 2000 cu. ft. per barrel and, in all cases where this figure was exceeded, the operator was required to repair the well before an allowable was assigned to it.

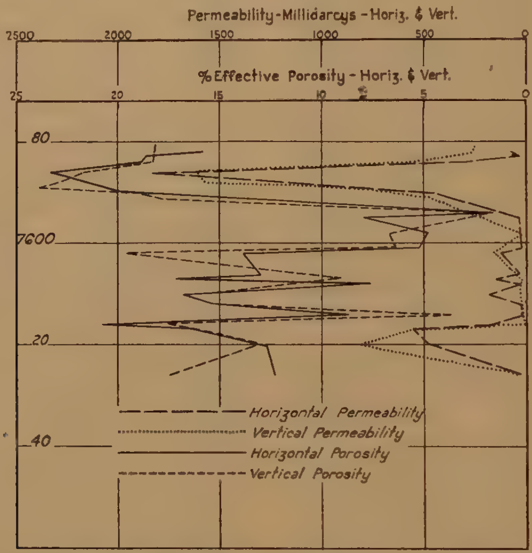

FIG. 1*a*.—CORE ANALYSIS, SHELL COMPANY'S L. GARRETT NO. 2.

It was suspected from the very start that the Magnolia field would produce by means of an active water drive and, although it was necessary to study the pool data for some time in order to prove this point, preparations were made in many of the wells to take advantage of the hydraulic energy. As shown in Fig. 1, the wells were cored and tested thoroughly, the cores analyzed in the laboratory and results of the porosity and permeability analysis plotted on the strip log. In addition to this, accurate drilling time was observed, so that in the event of missed cores a reasonably accurate estimate could be made of the relative porosity and permeability of the formations penetrated. After the information listed above had been plotted on the same strip log, it became evident that, although the producing formation as a whole has a thickness of porosity in excess of the 300-ft. combined gas cap and oil column, the impervious streaks that occur within this 300-ft. interval are of sufficient magnitude to prevent the vertical migration of the oil. As yet, correlation of the impervious streaks observed in the individual wells has not been established for any reasonable distance.

With these points in mind, an interesting procedure was utilized in some wells as follows: For wells that had casing cemented through the formation, perforating intervals were selected, so that each individual streak of permeability would be open to production. If the streak was relatively thin, it was perforated throughout its entirety. However, if the vertical permeabilities indicated that the streak had considerable thickness, approximately the upper 10 ft. of this streak was perforated. This procedure was established in order to drain the lowermost producing layers first and, as water encroached to the top of any one permeable streak, the latter could then be shut off by plugging back or setting a bridge plug in the casing and continuing the production from the next higher producing zone, in this manner progressively depleting the producing horizons from the bottom toward the top. By handling the wells in that manner, it is believed that less oil will be trapped in the formation by encroaching water. It should be pointed out here that close cooperation was required between the field and the laboratory, so as to have the cores from the producing formation forwarded to the laboratory and the results returned to the field during the three-day interval the casing was standing cemented.

Owing to the consolidated nature of the producing formation, no screens or perforated liners were necessary.

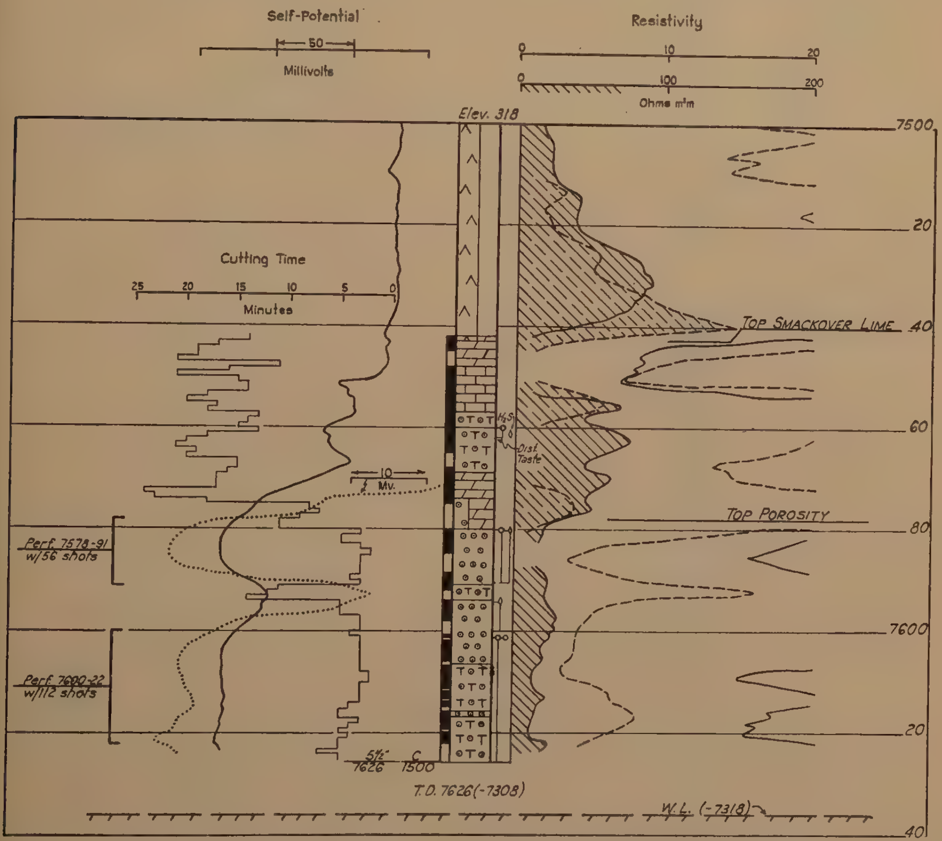

FIG. 1b.—BOTTOM-HOLE DETAIL, SHELL COMPANY'S L. GARRETT NO. 2.

SUBSURFACE GEOLOGY

Stratigraphy

Although this paper is not designed to give a detailed treatise upon the geological section in the Magnolia field, a short discussion covering the general features of the beds penetrated is essential to give a complete picture of engineering problems

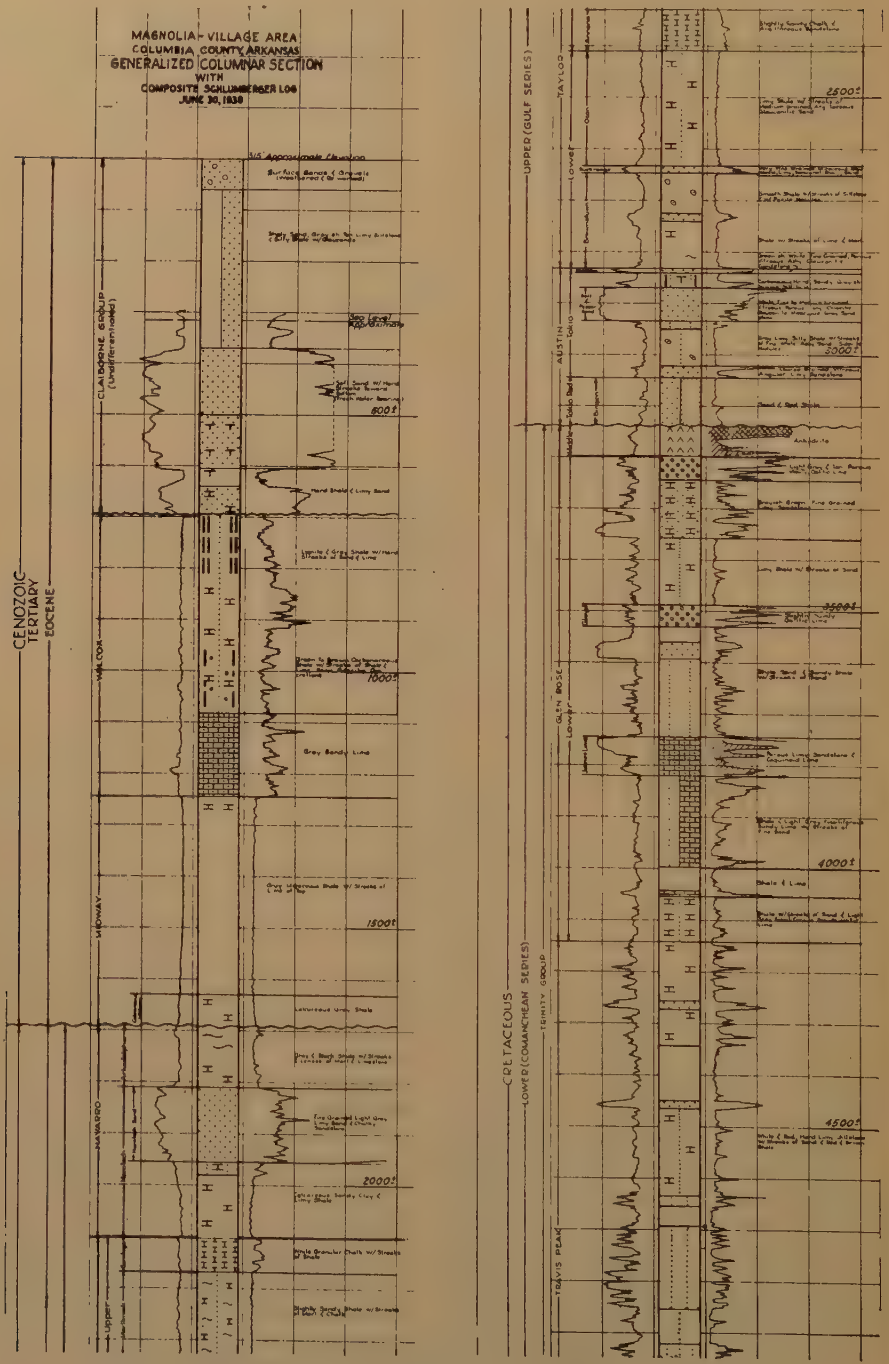
MAGNOLIA-VILLAGE AREA
COLUMBIA COUNTY, ARKANSAS
GENERALIZED COLUMNAR SECTION
WITH
COMPOSITE SCHLUMBERGER LOG
JUNE 30, 1938
315' Approximate Elevation
Surface Sands & Gravels (weathered & re-worked)
Sea Level Approximate
Hard Shale & Limy Sand
600±
Lignite & Grey Shale w/ Hard Streaks of Sand & Lime
1000±
Grey Sandy Lime
Grey Micaceous Shale w/ Streaks of Lime at Top
1500±
Calcareous Grey Shale
Grey & Black Shale w/ Streaks & Lenses of Marl & Limestone
Fine Grained Light Grey Limy Sand & Chalky Sandstone
2000±
Calcareous Sandy Clay & Limy Shale
White Granular Chalk w/ Streaks of Shale
Slightly Sandy Shale w/ Streaks of Marl & Chalk
CENOZOIC
TERTIARY
EOCENE
CLAIBORNE GROUP (Undifferentiated)
WILCOX
MIDWAY
NAVARRO
Upper
Slightly Sandy Chalk & Some Calcareous Sandstone
2500±
Limy Shale w/ Streaks of Medium Grained, Argillaceous Glauconitic Sand
Smooth Shale w/ Streaks of Siltstone and Pyrite Nodules
Shale w/ Streaks of Lime & Marl
3000±
Sand & Red Shale
Anhydrite
Light Grey & Tan Porous Oolitic Lime
Brownish Green Fine Grained Limy Sandstone
Limy Shale w/ Streaks of Sand
3500±
Shaly Sand & Sandy Shale w/ Streaks of Sand
Porous Limy Sandstone & Coquinoid Lime
4000±
Shale & Lime
4500±
White & Red, Hard Limy Siltstone w/ Streaks of Sand & Red & Brown Shale
UPPER (GULF SERIES)
TAYLOR
Lower
AUSTIN
Tokio
Middle
GLEN ROSE
Lower
CRETACEOUS
LOWER (COMANCHEAN SERIES)
TRINITY GROUP
TRAVIS PEAK

FIG. 2.—GENERALIZED COLUMNAR SECTION MAGNOLIA VILLAGE AREA.

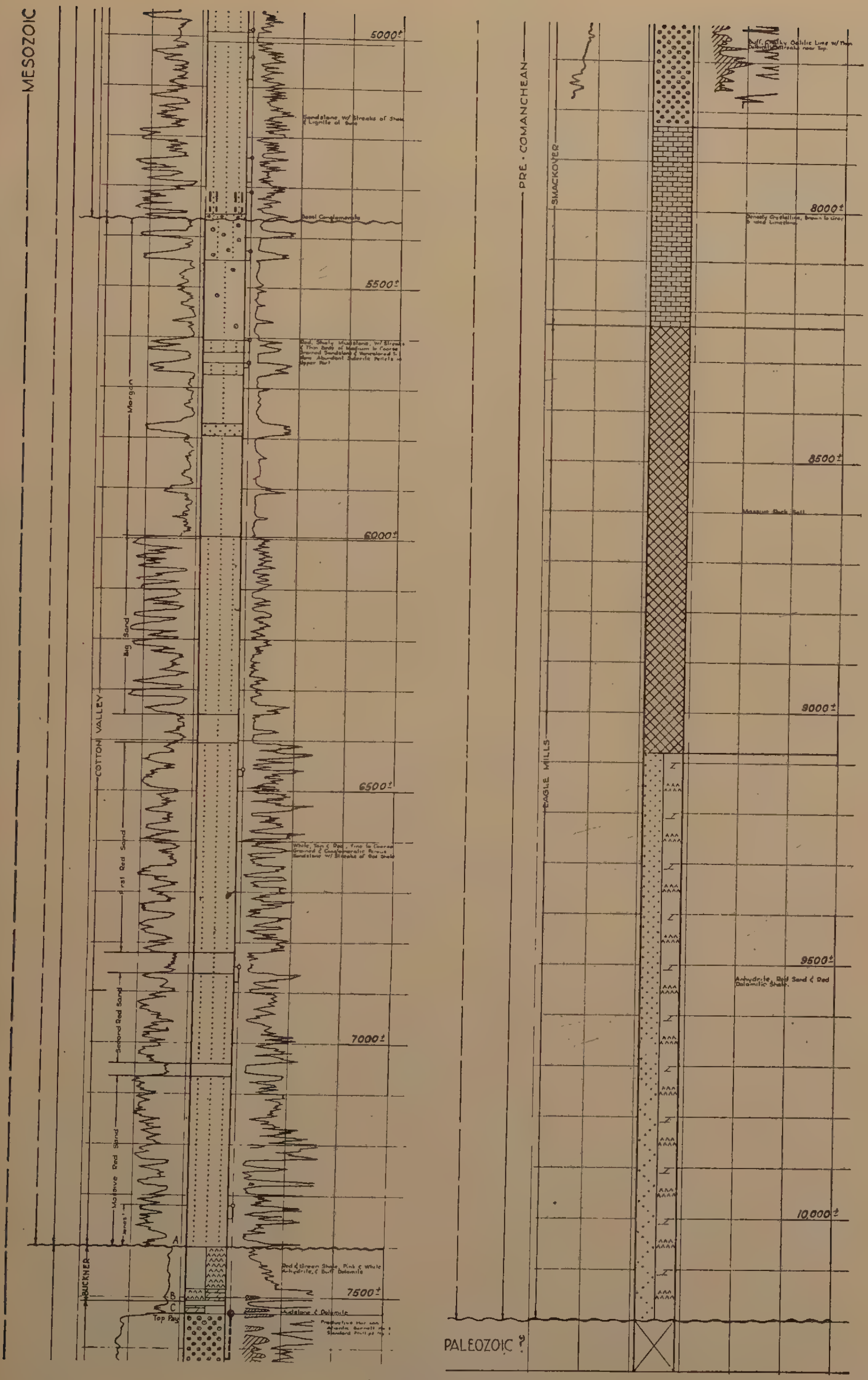

FIG. 2.—*Continued.*

encountered during the development of the field. In Fig. 2 is illustrated a generalized columnar section of the Magnolia-Village area in Columbia County, Arkansas, and the following constitutes a brief summary of the stratigraphy.

The series of Cretaceous strata encountered in this field is similar to that found to the southwest in the main part of the Woodbine, or East Texas Basin. The most noticeable exceptions to this occur above and below the major Gulf-Comanchean unconformity, which truncates successively older beds in the Comanchean series proceeding from East Texas to Arkansas.

From the Upper Cretaceous, or Gulf Series, all the beds of Eagle Ford and Woodbine age are missing, and from the Comanchean nearly 2500 ft. of Washita-Fredericksburg and Upper Glen Rose strata have been eroded, leaving only the Massive Anhydrite of Middle Glen Rose age, and, in a few localities, a small amount of Upper Glen Rose lime.* In the Rodessa field, 45 miles to the southwest, less than 500 ft. of the Washita-Fredericksburg had been removed before Gulf time, and the Trinity remained intact.

Below the Comanchean series lies a group of beds, the age of which is still somewhat doubtful. For convenience, they are called pre-Comanchean, but it is believed that they are probably of upper Jurassic age. This series of beds includes the Buckner, Smackover, and Eagle Mills formations. The last formation has not been penetrated in this field, but is placed in the section on the basis of near-by deep tests.

Production in this field, to date, has been found only in the Smackover lime,

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* The field nomenclature used to describe the various formations has been carried out in this paper. For this reason the various limestone bodies have been called simply "lime" with the term "limestone" used to indicate only the hard, dense, crystalline formations.

Stratigraphic Column

Age	Series	Formation	Approximate Thickness, Ft.	Member
EOCENE		Claiborne	700	
		Disconformity		
		Wilcox	540	
		Midway	450	
		Disconformity		
CRETACEOUS	Gulf	Navarro	120 290	Arkadelphia Nacatoch
		Upper Taylor	70 155 85	Saratoga Marlbrook Annona
		Lower Taylor	220 20 180	Ozan Buckrange Brownstown
		Austin	310	Tokio
		Major Unconformity		
	Comanchean	Upper Glen Rose	0–30	
		Middle Glen Rose	125	Massive Anhydrite
		Lower Glen Rose	940	Gloyd lime James lime
		Travis Peak	1,220	
		Unconformity		
		Cotton Valley	2,040	Morgan sands Big sand First red sand Second red sand Massive red sand Jones sand
		Unconformity		
JURASSIC ?	Pre-Comanchean	Buckner	110	Anhy. and shale
		Smackover	10 340 400	Dolomitic shale Oölitic lime Crystalline lime
		Eagle Mills	800 1,100	Salt Anhydrite, etc.
		Major Unconformity		
PALEOZOIC				

although shows have been reported and tested in the Glen Rose and Cotton Valley formations.

The stratigraphy of the Smackover lime, as outlined in the accompanying columnar section, consists of dolomitic shale, oölitic lime and crystalline lime. The dolomitic phase is hard, dense, and nonporous, and is directly underlain by the oölitic facies, sometimes known as the Reynolds lime. The latter is a porous oölitic and pisolitic lime with hard, dense, firmly cemented streaks varying in thickness from a few inches to 60 ft. Occasional streaks of cavernous, coral-reef material also occur, as well as layers of dense, crystalline lime, with inclusions of anhydrite, gypsum, calcite, pyrite, and lignite. Stylolites and sections with asphaltic matrix are not uncommon. The porous and permeable zone in the oölitic member usually commences near the top, but may be found as much as 60 ft. below the base of the dolomitic shale. This porous and permeable zone in the Reynolds lime of the Smackover is the source of the Magnolia field production.

Attempts have been made to correlate the dense streaks and coral reefs, but as yet have not met with success. Unfortunately, these layers are not always recognizable on the electrical logs, and core logs on some wells are not complete.

The greatest thickness of oölitic lime drilled, or cored, in the Magnolia field is about 340 ft. Deeper exploration indicates dense, crystalline lime below this point, and there is no evidence from other areas that other deeper porous zones exist. The main body of the crystalline lime, and lower strata, have not been penetrated in this field.

Markers

As development in this area rapidly evolved with the Smackover lime as the primary objective, it was not necessary to follow the detail markers of the stratigraphic column too closely. The chalks at 2000 to 2300 ft. were characterized by hard drilling, hence the casing point for the intermediate string was easily determined. Except for the testing of the various sands throughout the Comanchean series, where minor showings occasionally were encountered, drilling usually progressed rapidly to the Buckner formation, which was easily distinguished from the Cotton Valley series. It became the common practice, therefore, to drill the wells to or almost to the top of the Smackover lime before coring. The latter formation in most cases was completely cored by conventional methods with a large-sized core barrel. Electrical logs were run and the exact position of the upper markers determined after the total depth had been reached.

Structure and Accumulation

The subsurface structure of the Magnolia field (Fig. 3) is based upon the top of the Smackover lime, which occurs at an average depth of 7150 ft. subsea in an anticlinal fold. The anticline is elongated in an east-west direction, the axis swinging slightly to the south on the eastern end. The average dip on the north flank is about 6½° and on the south flank about 4°. The crest of the structure is in the vicinity of the NE¼ of the NE¼ of sec. 23, where the top of the Smackover lime was encountered at 6986 ft. subsea in Frank Frankel et al., Levi Garrett No. 1. The lowest structural point is along the north flank in Atlantic Refining Company's Baker No. 1, a dry hole that encountered the top of the Smackover lime at minus 7358 feet.

The areal extent of the producing acreage in the field is estimated to be 4494 acres (Fig. 3). The limits of the field have been determined by dry holes on the north and east flanks and by the establishment of the water level in producing wells on the south and west flanks. The field is peculiarly free from faulting of any consequence. The

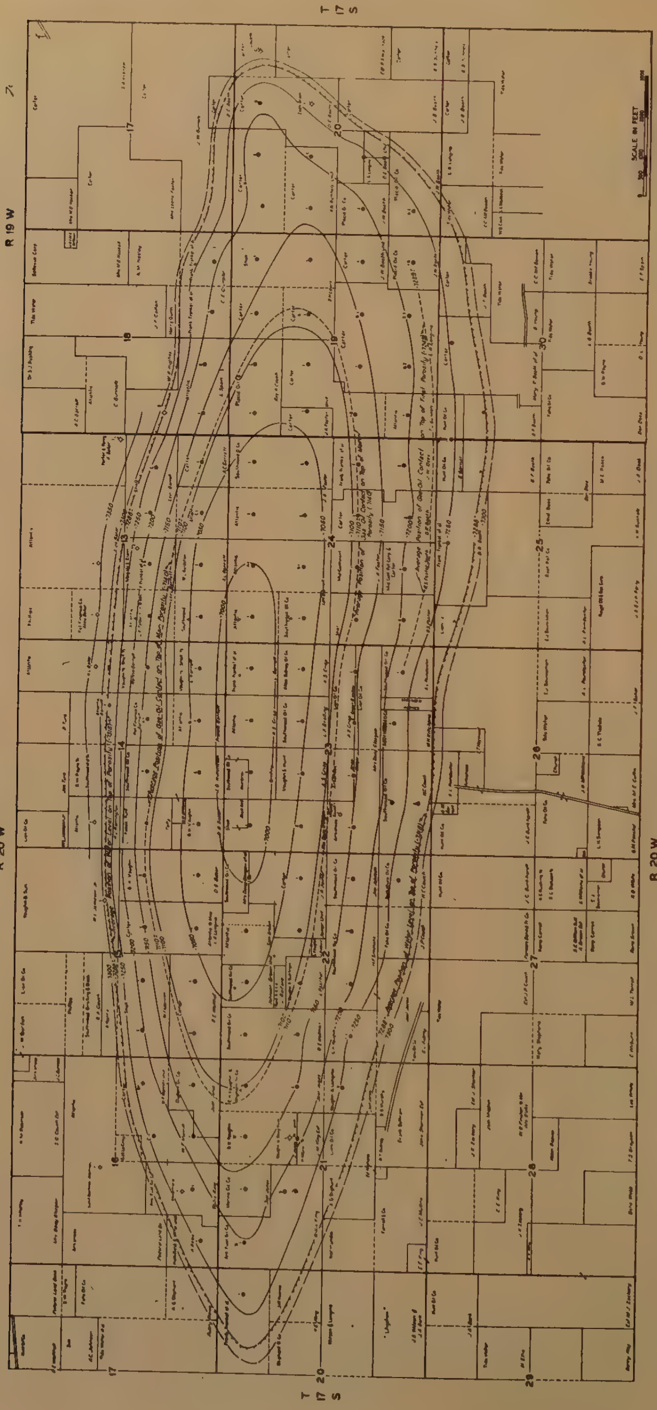


FIG. 3.—SUBSURFACE STRUCTURE MAP OF MAGNOLIA FIELD.

known maximum structural relief is 372 feet.

The top of the Smackover lime was selected as a marker on which to contour the structure, because of its relative proximity to the producing zone (about 30 ft.), and also because it is a true lithologic break, which could easily be determined in the field from drilling time, coring and electrical logs. Contours were also drawn on an electrical marker at the top of or close to the Smackover lime porosity. This datum proved very satisfactory in most instances, and gave a slightly more accurate picture of the top of the porosity but, because of some variation, it was less accurate in predicting structural position of new wells than the top of the Smackover lime. Core analyses showed that this electrical log marker did not always represent the true top of the porous and permeable zone.

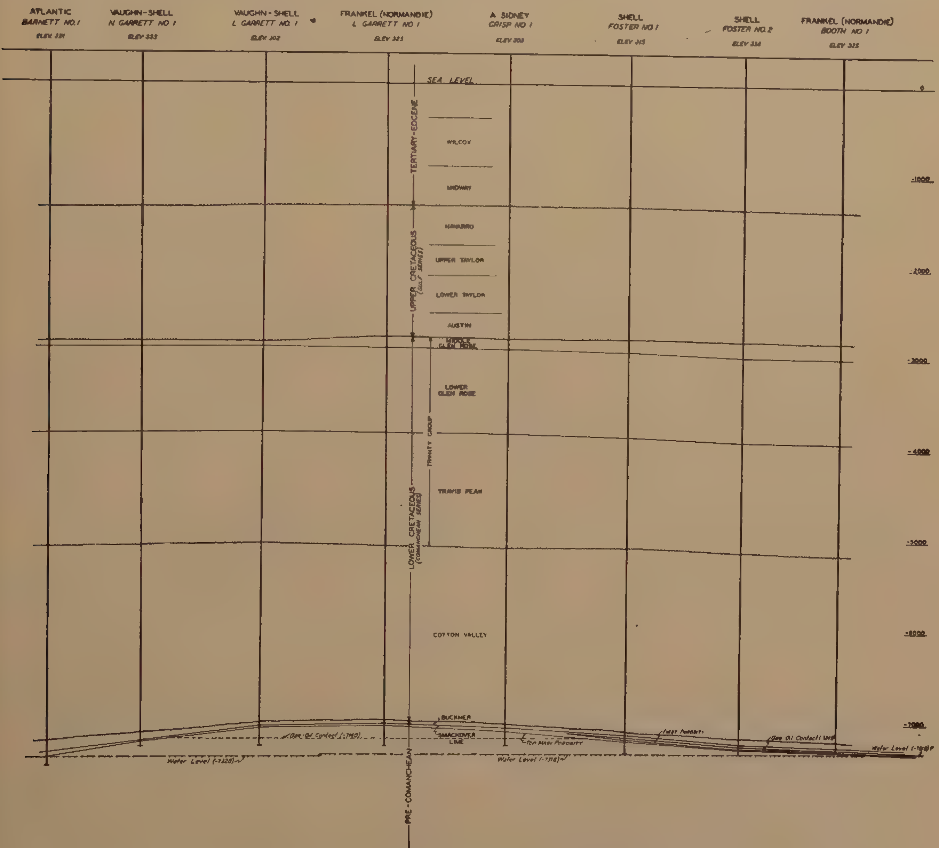


FIG. 4.—NORTH-SOUTH SECTION THROUGH MAGNOLIA FIELD.

It was labeled, for practical purposes, "Top of the Pay," and the structure closely resembles that shown on Fig. 3. The largest variation between this marker and the actual top of the porous and permeable zone does not exceed 15 ft. On the subsurface map in Fig. 3, the contours are shown on top of the Smackover lime because it was the most widely used horizon during the development of the field, but it must be noted that this datum is approximately 30 ft. above the actual top of the producing formation. The average position of the gas-oil contact on the top of the main porosity, and the average position of the water level on top of the porosity, as shown on the map, correspond, therefore, with the Smackover contour 30 ft. shallower.

Fig. 4 is a schematic, north-south cross section through the approximate center of the Magnolia field. The details of the wells shown on this cross section have been eliminated so that pertinent data could be better illustrated. Originally this section was made of standard strip logs, which resemble the type of columnar section shown in Fig. 2, and gave all the details of electrical logs, coring, testing and paleontological markers. The top of the porosity is shown on Fig. 4 as well as the top of the Smackover lime, and the gas cap, oil column and water levels are indicated. The deeper structure is not reflected through the upper beds and the first semblance of it appears on the top of the Buckner anhydrite, which lies directly above the Smackover lime and is composed principally of red shales and anhydrite.

The cross section indicates the thinning of the anhydrite over the crest of the structure; although not shown on these illustrations, the anhydrite continues to thin regionally updip to the northeast. As demonstrated on the columnar section, the top of the Buckner anhydrite is an erosional feature, which varies throughout this general area. In the Village field, 6 miles to the east, the maximum recorded thickness is 135 ft., whereas at Magnolia the maximum thickness is 155 ft. Six miles to the southeast, in the Atlanta field, and in the Schuler field, 15 miles southeast, no Buckner zone is found. The Buckner zone forms a complete impervious cap over the entire structure and could have acted in the capacity of a cap rock.

Although not shown on the cross section, there is some evidence to indicate that what little structural anomaly appears in the succeeding younger beds has shifted to the south or southwest with depth. This is a feature that has been recognized throughout the general region in other fields. Until the top of the Buckner anhydrite was encountered, through the drilling operations, therefore, the structural position of any well was indefinite, and the true position was not determined until the top of the Smackover lime had been encountered.

Producing Horizons

Smackover Lime.—The top of the Smackover lime is readily discernible by the abrupt change from red shales and anhydrite to dense crystalline limestone. Although it varies from well to well, the top 30 ft. of the Smackover lime is dense and contains no porosity, permeability or showings of oil and gas and generally increases in hardness from the top downward. After about 30 ft. of penetration in the Smackover lime, the character of the limestone grades from a crystalline to an oölitic lime; a gradational feature that is one of the reasons for the variation in distance from top of the Smackover lime to the top of the productive zone. The top of the oölites has at times been designated as "top of the Reynolds lime," but this nomenclature has not been widely used.

The remainder of the section penetrated in the Smackover lime (or Reynolds lime) consists of oölitic lime, pisolitic lime, streaks of coquina and some streaks of crystalline limestone. As mentioned under Development, no general correlation can be established between the impervious streaks encountered, and the main porous zone must be considered as continuous from top to bottom; even if this is not true in one well, the connection is believed to exist elsewhere in the structure. In general, the impervious streaks in the producing horizon are attributed to secondary deposition of calcareous material in the porous spaces. However, some crystalline limestone streaks have been observed in cores where oölitic structure is absent. Black materials (called asphaltic) also form impervious streaks in the porous section.

In Fig. 1 a typical bottom-hole detail is shown, which demonstrates the existence of a hard, impervious streak in the producing formation. To the left of the bottom-hole detail are also shown analyses of the cores taken from the well, which indicate the varying porosities and permeabilities. The cutting time observed during the progress of coring is also plotted on the well log, in order to indicate the occurrence of hard, impervious streaks.

As shown in the schematic cross section of Fig. 4, the maximum thickness of the gas cap is 120 ft., whereas the thickness of the oil column varies from 178 to 188 ft. The variance indicated in the water level is due to the lack of data on the north flank concerning the exact position of the water level. The figure of 7318 ft. subsea for the oil-water contact was taken from several wells that have penetrated the water level in the main portion and southern flank of the reservoir, and, although it is applicable for the main porous section, the discovery well may be producing oil from as low as 7328 ft. subsea.

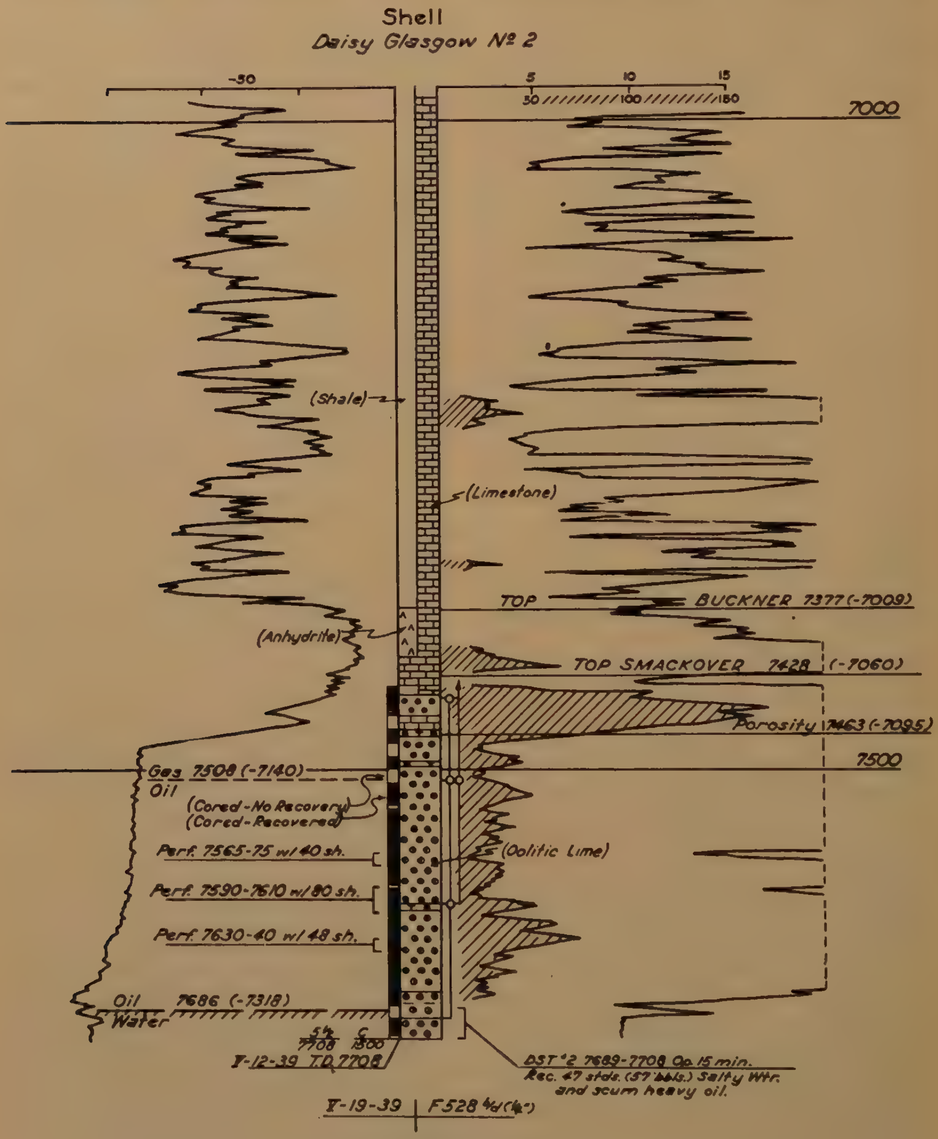
The accuracy of the data for the discovery well is questionable, but it is altogether possible that this well may be producing from a porous and permeable streak in the Reynolds lime, above the main producing horizon on the flanks of the structure. A detailed study of the cross sections across the field indicates that on the south flank there is definitely an upper porous and permeable streak that is not connected in its upper portions with the main productive zone and, as indicated in Fig. 4, carries a separate gas cap with a gas-oil contact at 7249 ft. subsea. The existence of this secondary gas cap on the south flank has been definitely proved in several wells, therefore it is altogether reasonable to expect that the same condition could exist on the north flank of the structure with a separate water level. This point has yet to be proved, so for all purposes of estimation the water level has been assumed to be at 7318 ft. subsea throughout the field.

So far as is known, the water level in the upper zone on the south flank is the same as in the main body of the reservoir but on the southwestern flank of the structure, an exceptionally high water-oil contact, varying from 7297 to 7308 ft. subsea, has been determined by both electrical logs and production data. The reason for this condition has not been thoroughly explained, but it does exist and has given considerable trouble during the producing life of some of the wells drilled on that flank. Undoubtedly the existence of impervious streaks close to the water level has obscured the true oil-water contact in places, and water was not encountered until the well had been carried to the next permeable streak. Owing to the fact that the 7318 figure was established by electrical logs and drill-stem testing in a continuous porous section, during the early stages of development in the field, it is felt that this determination can be considered the most accurate.

A detailed study of the cross section across the field reveals that, in the 30-ft. interval between the top of the Smackover lime and the top of the main porosity, an oölitic streak is developed on the north and south flanks of the field, which diminishes in thickness toward the crest and disappears entirely on the highest portions of the structure. Within this upper porous and permeable streak the secondary gas cap was developed on the south flank.

The upper streak of porosity is not as well developed on the north flank as on the south flank but there is sufficient evidence of its existence to indicate that it may be productive in a few of the wells.

The interpretation of some of the earlier electrical logs in the producing horizon was difficult at first because of lack of experience with this type of reservoir. The self-potential curves in particular indicated relatively high permeability throughout the reservoir section, although it was known that impervious streaks existed. However, with the development of a more sensitive self-potential reading (Fig. 1), the permeable streaks were brought out more clearly. It has been estimated that the effective producing section of the main porosity is approximately 125 ft., or roughly 70 per cent, of the porous section throughout the field. The asphaltic and dense streaks encountered in almost every well accounted



Scale: 1 in. = 100 ft.

FIG. 5.—DATA PLACED ON WELL RECORD MAP AND ELECTRIC LOG.

for most of the impervious portions in the main reservoir. The amount of penetration of the producing section taken in each well varied according to the policy of the various operators. It is believed that wells bottomed as much as 100 ft. or more above the known water level will have to be deepened eventually in order to drain the reservoir effectively.

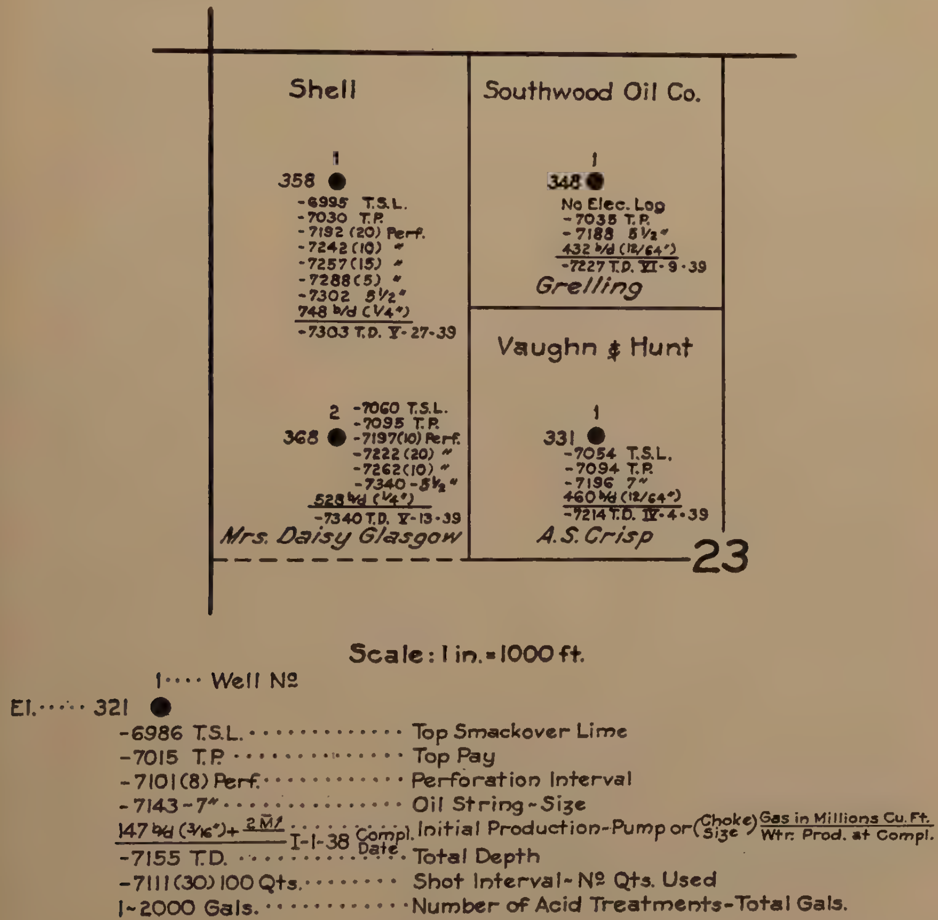


FIG. 5.—*Continued.*

The characteristics of the producing horizon, based upon all core analyses available and as submitted to the Oil and Gas Commission, have resulted in the establishment of average figures as follows: porosity, 18.5 per cent; permeability, 1500 millidarcys, varying from 0 as a minimum to 16,000 as a maximum. Connate water has been taken at 20 per cent, based on laboratory tests.

Fig. 5 has been included to demonstrate a method of presenting pertinent information graphically on maps and electrical logs. By this, or similar methods, the data are available in a convenient and usable form on maps and cross sections.

Other Indications of Accumulations.—In general, recompletion possibilities in upper zones of wells drilled in the Magnolia field are not attractive. Various small showings were reported in the Rodessa, Cotton

Valley and Travis Peak sands and although these showings were not of sufficient magnitude to warrant the testing of the wells at that time, some interest has developed in shallow production because of the appearance of oil and gas between the casing strings of three of the Smackover lime producers. It is significant that, whereas the oil and gas from the Smackover zone carries a high concentration of hydrogen sulphide, the showings found between the strings of the three wells are sweet; that is, they do not contain hydrogen sulphide in appreciable quantities. A shallow test slightly north of the limit of Smackover production was drilled on the strength of these showings and was designed to test the Rodessa zone, which was considered to be the most likely source, but cores and electrical surveys of this section failed to indicate any productive possibilities. It appears now most probable that the source of this sweet oil and gas is some shallow, porous zone of small magnitude that is not recorded on the electrical survey.

PRODUCTION

Type of Oil

As indicated in the foregoing pages, the Magnolia field represents a normal type of accumulation; i.e., the oil has accumulated on top of water and a gas cap has formed in the crest. The oil varies in gravity from 38° to 41° A.P.I., with an average slightly above 39°. The characteristics of the crude are shown in Table 1, which is a brief analysis of the oil from three random wells in the field.

One unusual feature of the Magnolia crude is its salt content, which varies from 30 or 40 lb. to 400 lb. per 1000 bbl. Some concern was expressed early in the life of the field concerning this characteristic but satisfactory means of de-salting the crude at the refineries was established. The gas produced with the oil is composed of the normal lighter fractions of hydrocarbons contained in the oil under its reservoir conditions; it is not the gas that has accumulated in the gas cap. This gas has an average gasoline and butane content of about 3.10 gal. per 1000 cu. ft. A shrinkage factor of 34 per cent in volume of the original crude has been determined when it is removed from reservoir conditions to standard temperature and pressure.

TABLE 1.—*Analysis of Oil from Three Wells*
PER CENT

Crude	Well No. 1	Well No. 2	Well No. 3
Gravity, deg. A.P.I. at 60°F.	38.3	41.3	39.0
Sulphur, per cent by wt.	1.03	0.80	0.79
Pour point, deg F.	0	0	15
Saybolt Universal viscosity:			
At 40°F.	62	56	60
At 60°F.	48	43	47
At 80°F.	42	39	42
Laboratory Yields			
Gasoline (net), 400°F. EP, per cent	32.6	37.1	32.3
Kerosene, per cent			16.5
Furnace oil (max.), per cent	19.3	17.1	
Gas oil, per cent	1.9	4.0	8.3
Residue, per cent	45.7	40.8	42.2
Water, per cent	0.0	0.0	0.1
Loss, per cent	0.5	1.0	0.1

Proration

Before establishment of proration orders for the Magnolia field by the Arkansas Oil and Gas Commission, production from the discovery well was restricted to 200 bbl. per day for several months. During December 1938 the Arkansas Oil and Gas Commission established proration regulations for the Magnolia field. Provisions were made to measure bottom-hole pressures at regular intervals and the Commission ordered production allotted on the basis of 40-acre units. The allocation of production between wells was as follows: the allowables were based half on each well's share of the sum of bottom-hole pressures and half of each well's share of the sum of producing acreage when applied against the total field allowable for a given month. It was also provided that wells with gas-oil ratios greater than 2000 cu. ft. per barrel be penalized. At that time the average per well allowable was set at 250 bbl. per day. The per well allowable fluctuated from month to month, depending upon market demand and pipe-line capacity, and for a period during February 1939 it was increased to a maximum of 375 bbl. per well per day. This was reduced to 300 bbl. per day the following month and remained at this amount for several months. As more wells were completed and the market demand supplied, allowables per well were gradually reduced until December 1941, when the allowable was approximately 165 bbl. per day.

The trend of production during the period of development is illustrated in Fig. 6. The total field production was allowed to increase with development until it had reached approximately 21,000 bbl per day, after which the rate was held more or less constant.

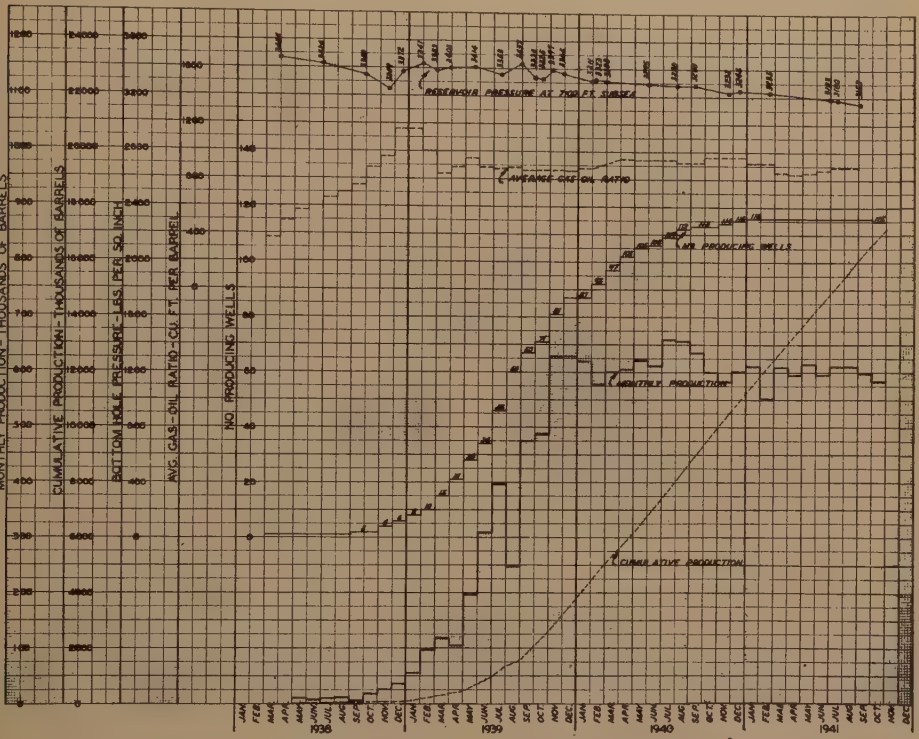


FIG. 6.—MONTHLY AND CUMULATIVE PRODUCTION, BOTTOM-HOLE PRESSURE, AVERAGE GAS-OIL RATIO AND NUMBER OF PRODUCING WELLS.

The scheme of proration just described remained in effect until April 1939, when the method of allocation was based on acreage times reservoir pressure. This was accomplished by measurement of reservoir pressures in key wells at stated intervals under the supervision of the Arkansas Oil and Gas Commission; results were then contoured on a map and each well's pressure determined. The estimated pressures and acreage units assigned to individual wells then formed the basis for each well's share of the field allowables. It was anticipated that this method of proration would be more satisfactory than the one previously used, but under the existing conditions it had very little effect on the allowables assigned to individual wells because the pressures over the field did not vary any considerable amount. However, if a certain area was receiving too great an allowable, which, in turn, caused the bottom-hole pressures to be lowered more rapidly than in other parts of the field, this area automatically received a cut in allowable tending to equalize the bottom-hole pressures throughout the field and minimize the amount of drainage across lease lines. As both plans of allocation in the Magnolia field placed considerable emphasis on acreage, they served to encourage unitization of small tracts into 40-acre drilling units, even though the Oil and Gas Commission had other machinery set up to provide for this unitization.

The original bottom-hole pressure was found to be 3465 lb. at 7100 ft. subsea. The results of subsequent periodic measurements are shown in Fig. 6. As of December 1941, the bottom-hole pressure had declined a total of 336 lb.; that is, to 3129 lb. per sq. in. The cumulative production for the same interval amounted to 18,377,000 bbl., from 116 oil wells. Based on these figures for the reservoir, a productivity of 54,694 bbl. of oil produced per pound drop in pressure has been calculated. In recent months, however, the productivity of the reservoir has increased. From February 20, 1941, to July 15, 1941, the productivity averaged 65,500 bbl. of oil per pound drop. More recent indications are that its rate of productivity will be continued or may still further increase. These data, although not conclusive, indicate the reaction to withdrawals of the various factors affecting the productivity of the reservoir and serve to show the ability of the reservoir to sustain production. The increase in productivity probably is due to a better balancing of pressures throughout the field since complete development, and a consequent spreading of withdrawals over the entire reservoir.

The original gas-oil ratio observed on the discovery well averaged approximately 700 cu. ft. per bbl. but increased throughout the succeeding months to 1150 cu. ft. per bbl. by January 1939. With the completion of additional wells the average ratio declined to approximately 850 cu. ft. per bbl. and has fluctuated between this amount and 950 cu. ft. per bbl. The present ratio for the field is 889. Based upon the relatively small decline in bottom-hole pressures and the stationary position of the average gas-oil ratio of the field, it may be concluded that the Magnolia field as a whole is being controlled according to the better principles of conservation. Even though the oil accumulation is overlain by a large gas cap, there has been no appreciable change in the average gas-oil ratio, and it appears that the field is being produced at an efficient if not an optimum rate of production.

The strict control exercised by the Arkansas Oil and Gas Commission over the gas-oil ratios, with its rigid penalties for wells that exceed the gas-oil ratio of 2000 cu. ft. per bbl., has stimulated the use of remedial measures to correct excessive ratios. Judging from the record of bottom-hole pressures and the performance of the wells, it is probable that the field has benefited by the presence of a strong water drive, which should serve as an unlimited source of energy and, if controlled properly, will increase the recoveries from the field.

Disposal Facilities, Oil and Gas

The Magnolia field is served by six pipe lines, which take all of the crude produced in the field. All of the gas is processed in a gas plant in the central part of the field, which handles an average of 17,000,000 cu. ft. per day. After passing through the plant, approximately 12,000,000 cu. ft. is sold for commercial use and the rest of the gas is returned to the operators in the field for their use or for use as fuel in the plant. This plant is designed to carry a maximum capacity of 20,000,000 cu. ft. per day. It is of the high-pressure, absorption type and operates at about 200 lb. pressure. The gasoline and butane content of the gas averages 3.10 gal. per 1000 cu. ft. The yield of the plant, therefore, is approximately 52,000 gal. per day, of which 30,000 gal. is natural gasoline and 22,000 is butane. The products of the gasoline plant are sold to the trade in railroad tank cars.

ECONOMICS

The cost of drilling wells in the Magnolia field approached the average for wells of this depth in this type of formation. The earlier wells, which of necessity were of an exploratory or semiexploratory nature and therefore entailed a larger amount of coring and testing, as well as the larger casing scheme, cost in the vicinity of $75,000 to $80,000. As drilling proceeded and contract prices were lowered because of the familiarity of the various drilling companies with the formations to be penetrated, the average cost of completing a well to tanks was reduced to approximately $65,000, even though some operators were still utilizing the larger casing scheme. Later, wells utilizing the smaller casing scheme were drilled and completed to the tanks for approximately $55,000. With the allowables as they existed during the period of drilling, and depending upon the size of the casing scheme chosen by the individual operator, pay-outs of from 1 to 1½ years were possible. During the early life of the field the posted price of crude oil was approximately 93¢ per barrel. With the increased demand for crude oil, prices have now been raised to $1.06 and $1.08, dependent on the gravity of the oil. The maximum posted price at the time of writing is $1.08 for 40° A.P.I. oil, with stipulated reductions of price as the gravity of the oil decreases.

RESERVES

The cumulative field production from March 1938 through December 1941 is approximately 18,377,000 bbl., based on figures furnished by the Arkansas Oil and Gas Commission. Taking the formation characteristics mentioned earlier, of 18.5 per cent average porosity, 20 per cent connate water and 34 per cent shrinkage, and an assumed recovery factor of 60 per cent, it has been estimated that the original reserves were about 180,000,000 bbl. Based on these figures, the estimated recovery per acre-foot is about 455 bbl. However, there is considerable reason to believe that these figures are conservative, inasmuch as ample allowance has been made for connate water and shrinkage. In view of the high permeability, and an efficient water drive, recoveries as high as 555 bbl. per acre-foot are now considered possible, which would increase the estimated original reserves to 220,000,000 bbl. From these figures, it may readily be seen that more than 90 per cent of the production to be obtained from the Magnolia field is yet to be produced.

Because of the type of reservoir and the water drive, as indicated by pressure performance as well as the encroachment of water into the flank wells, it is anticipated that some wells will be forced to employ artificial lift early in their productive life, and subsequent abandonments will take place as the production continues. The first abandonment of a producing well in the Magnolia field occurred during August 1941. This well, which was on the southwest flank and had produced water since completion, had declined until it was producing 125 bbl. of salt water and 6 bbl. of oil daily by gas lift. According to the latest reports available, 16 wells in the Magnolia field are producing a total of 2392 bbl. of salt water per day, in amounts varying from 3 to 760 bbl. per well. Salt-water disposal in this field has not yet become a serious problem, and no disposal facilities other than surface pits have been provided. The field is of such magnitude that, if conditions remain as they have been, it is reasonable to expect that the flowing life of the majority of the wells will be from 10 to 15 years, and that the productive life of some of the wells will extend over a period of from 25 to 30 years, or longer.

ACKNOWLEDGMENTS

In preparing this paper I wish to thank the Management of the Shell Oil Co., Inc., as it was with their permission that I was granted time and assistance to prepare the paper. I have drawn freely on their files of information, and particularly wish to thank the members of the Shell Exploration Department for their assistance. The Production Department staff of Shell Oil Co., Inc., have also furnished considerable information; and where applicable data have been taken from earlier Shell reports.

The Arkansas Oil and Gas Commission, especially its director, Mr. A. M. Crowell, contributed data; Mr. John F. Magale, of Shreveport, furnished information concerning the early exploration of the area, and Mr. D. A. McGee, of the Kerlyn Oil Co., furnished information concerning the drilling of the discovery well.

Caliper Logging

By C. P. Parsons,* Member A.I.M.E.

(New York Meeting, February 1942)

Abstract

Caliper logging is a practice of measuring the variations in the diameter of the open hole in a well. This information is useful for many purposes, among which are: Determining the volumetric capacity of the portion of open hole to be cemented; the amount of gravel to be used for gravel-packing a well; the size and location of seat for a packer to be placed in a well; studying the effects of nitroglycerin shots; studying the effects of acidizing; studying the cause of drill-pipe failures; studying drilling technique; geological correlations. This is a new practice in oil fields and is eliminating considerable guesswork.

Introduction

Caliper logging of the open hole in oil wells, recently introduced and now showing initial results in many sections of the country, is providing information that is filling a long-felt need in oil-well cementing and in numerous other oil-field practices. Briefly, it measures the variations in diameter of the open hole in a well. This direct physical measurement of the stratigraphic profile has considerable value for subsurface interpretations by the geologist, engineer, driller and others charged with the responsibility of properly completing and repairing oil and gas wells.

The caliper shown in Fig. 1 is run into a well in closed position. The four arms are released when logging is to start. These arms are independent of each other. As the calipers are pulled upward through the open hole, the arms are like nimble fingers feeling the changing profile of the hole. This mechanical action is in turn converted into an electrical circuit, which is connected to a recording mechanism at the surface.

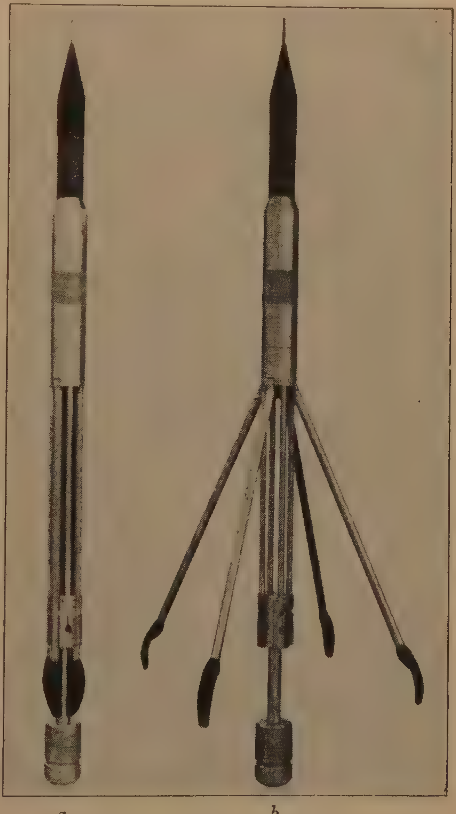


Fig. 1.—Open-hole caliper.
a. Lowered into well in closed position.
b. Arms released. Readings are made while caliper travels upward. Direct recording is made at surface, in inches.

The recording of the diameter of the hole is directly in inches.

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* Vice President, Halliburton Oil Well Cementing Co., Duncan, Oklahoma.

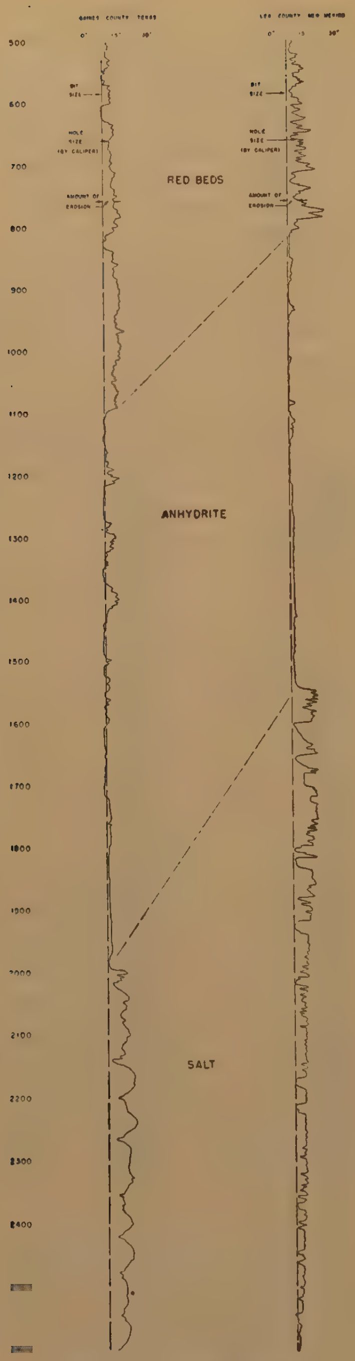


Fig. 2.—Caliper logs.

Fig. 2 shows two caliper logs. The placing of the two logs alongside each other indicates how these physical measurements can be used for geological correlations, but the logs were obtained for other primary purposes.

The log on the left of Fig. 2 was taken in a well in West Texas for the purpose of determining how much cement would be required to fill the annular space up to a certain level behind a string of casing to be run into the well. If the open hole were the same size as the bit by which it was drilled, only 250 sacks of cement would be required. The caliper log showed that 1100 sacks would be required. This is an extreme case, because the salt section is one of the most easily enlarged types of formation. It was important to know how much cement would be required to reach a certain height, because casing had collapsed in a near-by well owing to insufficient filling with cement. A formation below the intended level of the cement either caved or shifted in some way to collapse the casing. The amount of cement used in that well was 375 sacks, being 250 sacks based on bit size, plus 50 per cent added for irregularities in the open hole. As stated, the caliper log on the next well showed 1100 sacks.

The log on the right of Fig. 2 was taken in a well in New Mexico for the purpose of observing the enlargement of the salt section.

Fig. 3 shows a composite log from a well in Oklahoma, embodying three types of logs taken in the same well. The physical values in the caliper log are correlated with the electrical and thermal values in the electrical and temperature logs.

Figs. 4 and 5 are similar composite logs from Illinois and California.

Oil-well Cementing

Before the introduction of caliper logging, oil-well cementing had received considerable scientific development of equipment, materials and methods, but

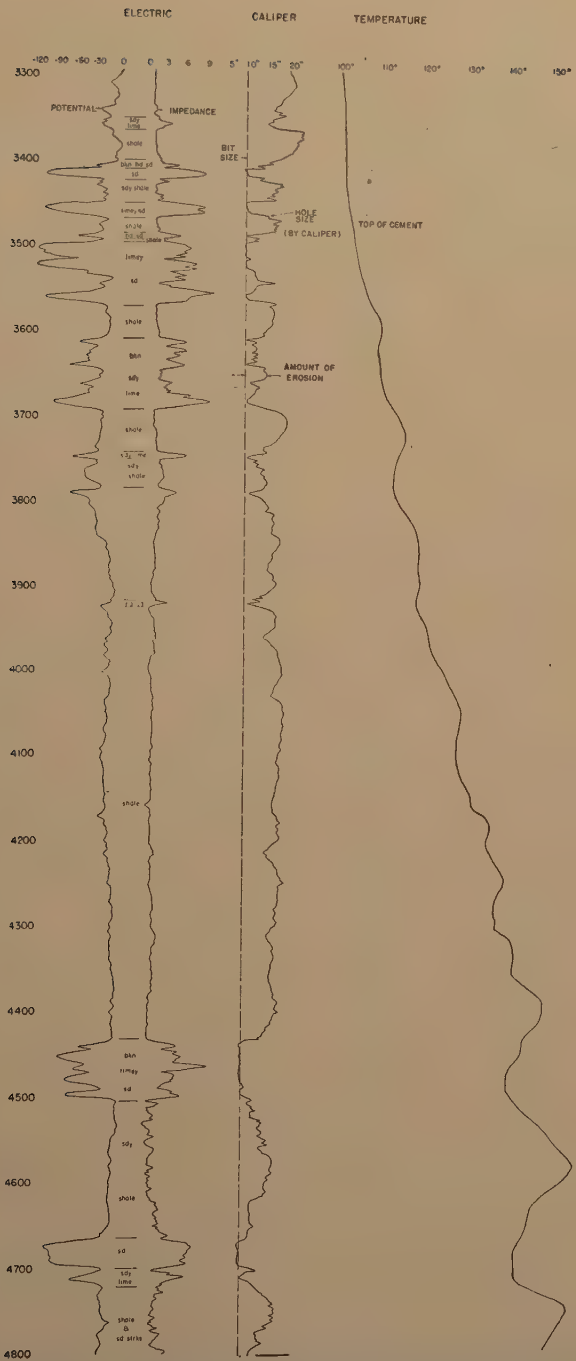


FIG. 3.—COMPOSITE LOG OF WELL DRILLED IN WEST CEMENT FIELD, OKLAHOMA.

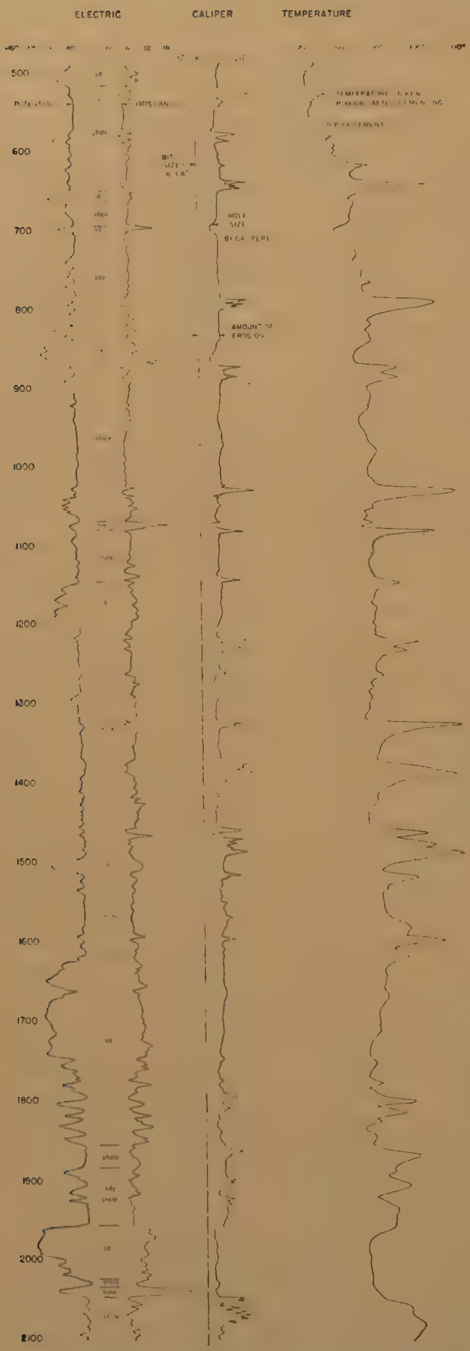


FIG. 4.—COMPOSITE LOG OF WELL DRILLED IN NOBLE FIELD, RICHLAND COUNTY, ILLINOIS.

there was considerable guesswork about the "landing field" for the cement in the bottom of a well.

The volumetric capacity of the portion of a well to be cemented was always an unknown factor. It was customary to say that a string of casing of a certain size was to be cemented in a hole of a certain size. For example, 7-in. o.d. casing in a 9⅞-in. hole. The size of the casing was actual, but the size of the hole was merely a reference to the size of the bit that drilled it. A similar reference was used when a plug-back job was being planned in the open hole below the casing. The amount of cement to be used was calculated from a cementer's engineering handbook, which was accurate, but the cement was pumped into a hole that was very inaccurate.

While the cement was setting, we crossed our fingers, hoping that the size of the hole was near the size of the bit that drilled it. We were aware that the hole varied from the size of the bit in different types of formations, but we never knew how much. Sometimes a guessed amount of cement was added to the calculated amount with the hope that it would take care of the unknowns. That groping in the dark has been a weakness in oil-well cementing ever since the first sack of cement was put into a well.

Caliper logging eliminates that weakness by measuring the actual variations in diameter of the open hole in a well. From that information the actual volumetric capacity of the portion of the hole to be cemented can be determined accurately.

The numerous caliper logs already taken in wells over an extensive area show that the difference between bit sizes and actual hole sizes is much greater than expected. In some wells the amount of cement calculated according to bit size was only 25 per cent of the amount based on actual caliper measurement, which means that 300 per cent more cement would be required to get the desired fill-up. The difference

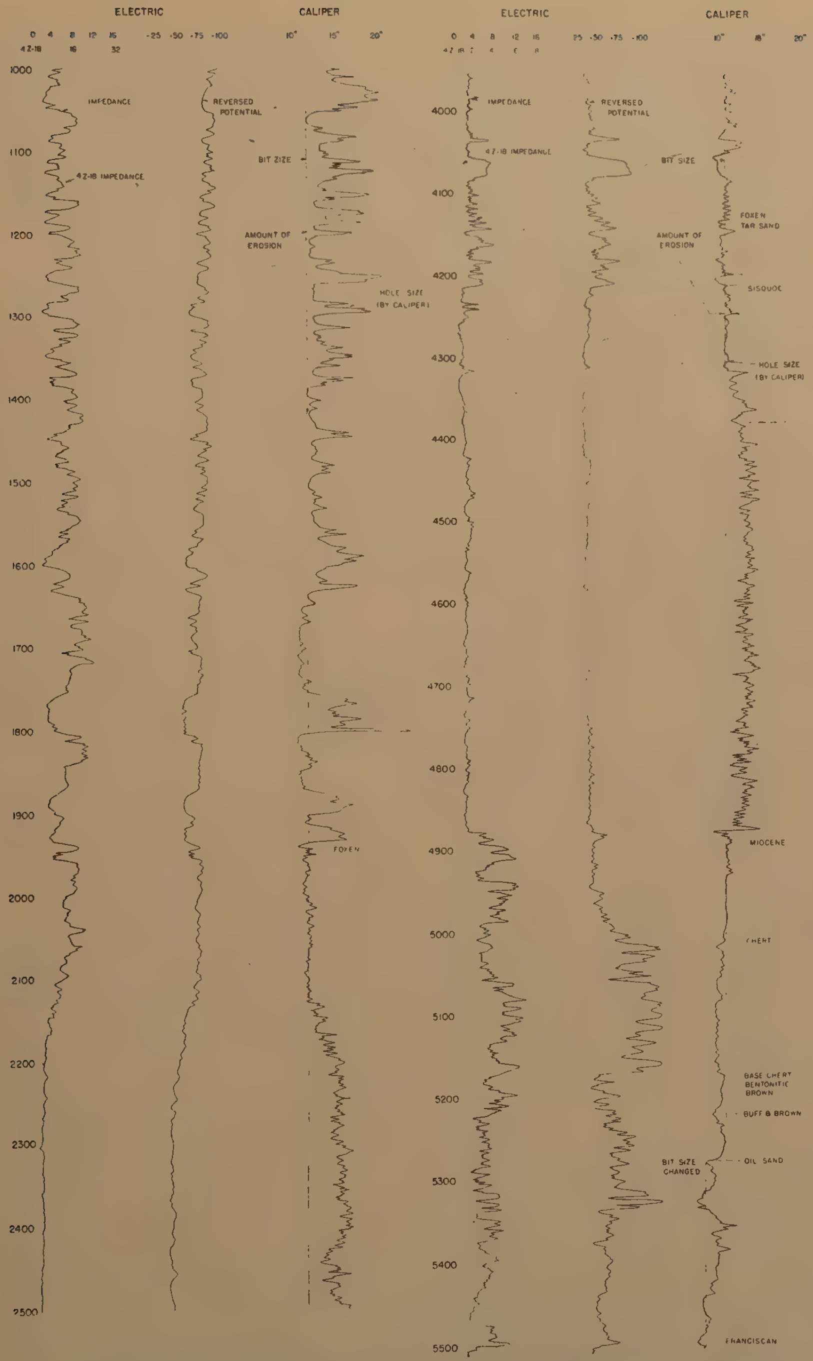


FIG. 5.—COMPOSITE LOG OF WELL DRILLED IN SANTA MARIA FIELD, CALIFORNIA.

varies in different wells, depending upon the amount of shale present, *but logs taken in all areas show that shales usually wash out considerably beyond the bit size,* while

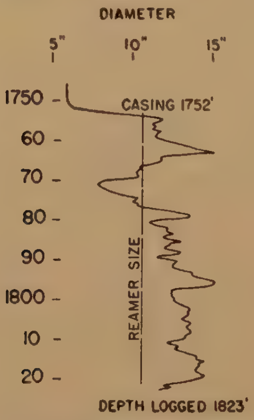


FIG. 6.—CALIPER LOG MADE PREPARATORY TO GRAVEL-PACKING WELL.

oil sands stand closer to bit size. Limes and other hard rocks hug the bit size. Shales drilled with a 9⅞-in. bit have washed out to 22 in. and averaged around 13 in. One significance of this is that one sack of cement fills 4.1 lin. ft. behind 7-in. o.d. casing in a 9⅞-in. hole, but fills only 1.17 lin. ft. in a 13-in. hole.

Since caliper logs show the actual volumetric requirements of cement, the information is helping considerably in solving the long debated question of where the cement goes when placed behind the casing in a well.

CEMENTING LINERS IN OLD WELLS

When a liner is to be cemented in the open hole below the casing, it is important to know the actual amount of cement required to fill the space behind the liner. The usual purpose of cementing such a liner is to shut off water or excess gas. The well is recompleted by perforating through the liner at levels that will produce pipe-line oil. Very often the space to be fiilled with cement behind a liner has been

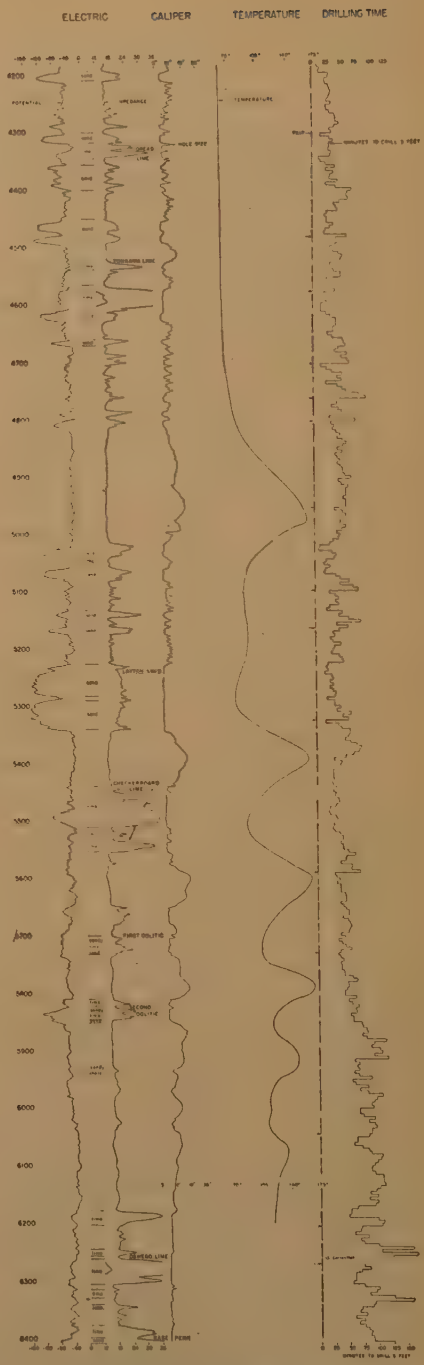


FIG. 7.—COMPOSITE LOG EMBODYING A CURVE SHOWING RATE OF DRILLING.

enlarged beyond its original size by three influences: (1) erosion caused by the circulating fluid jetting through the bit while the well was being drilled; (2) shooting with nitroglycerin; and (3) erosion by oil, gas and water while the well was producing.

GRAVEL PACKING

A caliper log provides basic information about the volumetric capacity of the portion of a well in which gravel is to be placed. It also shows the profile of the hole. The profile is important because certain shelf-like irregularities, if present, may have to be removed before full placement of gravel can be accomplished. Fig. 6 shows a caliper log taken as a preliminary step to gravel-packing a well in California.

ACIDIZING

Caliper logs taken before and after acidizing show the effect of acid on the diameter of the hole. These logs show whether or not the acid is entering a thin streak of high permeability in a formation and not entering the portion of low permeability that really needs the acid. In wells requiring large acid treatments, but which do not respond satisfactorily, it may be helpful to apply successive smaller treatments and obtain intervening caliper measurements as a possible check on where the acid is going. If it appears that the acid is entering a relatively thin portion of the formation, the proper size and place for a squeeze packer can be located so that acid can be squeezed into the portion of low permeability.

SIDE-WALL CORING

A caliper log shows not only the profile of sands, limes, and other formations, but also the length of the mechanical core takers required to reach from the coring device to the wall of a formation.

DRILL-PIPE FAILURES

One of the major problems of drilling oil wells is failure of drill pipe through fatigue. Part of this problem is the excessive wobble of the drill pipe, which is caused by parts of the hole that are considerably larger than the size of the bit that drilled it. The extensive study that has been made of this problem has been concentrated mostly on the steel and the design used in the drill string, but there is an important relation between the drill string and the irregular size of the hole in which it is rotating. The calipers make possible the study of the enlarged parts of a hole that cause excessive wobble.

Fig. 7 shows a composite log that also embodies a curve showing rate of drilling. This type of comparison may divulge some useful information in studies of drilling technique.

SHOOTING WELLS WITH NITROGLYCERIN

It has always been felt that an explosion of nitroglycerin in a well enlarges the borehole, but the extent of the enlargement has never been known. Caliper logs show not only the amount of enlargement but also its variations. This information is useful for studying the effectiveness of shots and different types of tamps. When a caliper log shows that the hole is enlarged only in some parts of the formation adjacent to the shot, it becomes apparent that those parts reacted differently from others. This lack of uniformity can be studied.

DRILLING IN SALT SECTIONS

This type of formation goes into solution when in contact with water in the drilling mud and thereby becomes considerably enlarged. A caliper log shows the extent of the enlargement. By successive changes in drilling technique when drilling in salt formations or cavey shales, and by successive caliper runs to determine the effect of each change of technique, the results can be measured and the proper technique developed.

Packer Settings and Formation Testing

For many years all sorts of carefully machined packers with limited expansibility have been run in open holes, the diameters of which were unknown. Often the expansibility of the packer was sufficient to reach the enlarged hole but frequently it "did not hold," for reasons that were unknown. It simply did not expand to fill the formation. The calipers are being used to measure and locate seats for packers.

Geological Correlations

Caliper logging shows the tops and bottoms of formations for geological purposes. The physical profile of a hole usually contains a continuous series of peaks and valleys which represent different formations. These are caused by the varying reaction of different formations to the drilling bit and by the hydraulicking of the drilling fluid as it is jetted out of the bit. The size of the bit may remain constant, except for wear, but the diameter of the hole does not.

Caliper logs made in several wells in an area provide stratigraphical information that can be correlated from well to well until a cross section of the area is obtained.

Acknowledgment

Acknowledgment is due the pioneering work done in open-hole calipering by Myron Kinley, the famous oil-well shooter and fire fighter, who gave freely of his time and money to develop the idea. His early efforts were with mechanical calipers, but later a joint experimental program between Kinley and Halliburton produced the present calipers, which combine mechanical and electrical principles.

APPENDIX

The following illustrations (Figs. 8 to 17) were presented at the New York Meeting, Feb. 16, 1943, as "Further Developments in Caliper Logging."

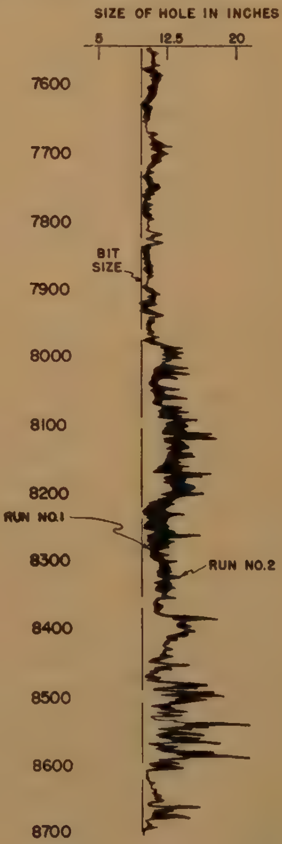


Fig. 8.—Two successive caliper logs taken 24 hours apart, showing effect of erosive action on diameter of hole in Chambers County, Texas.

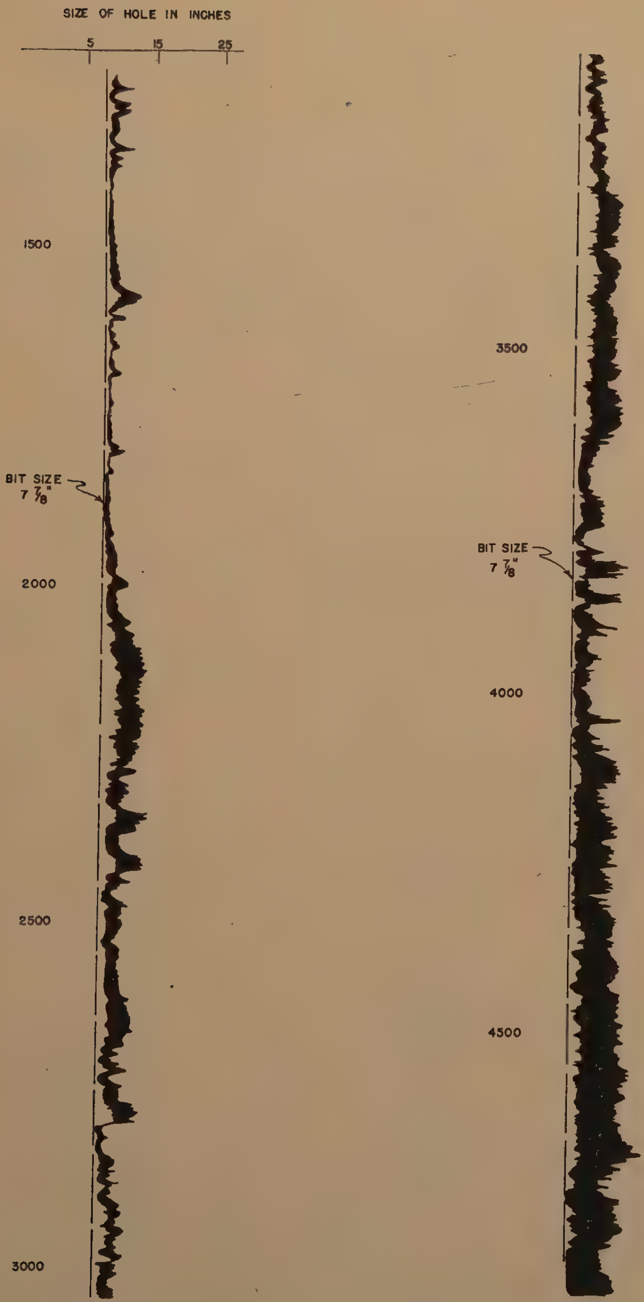


Fig. 9.—Two successive caliper logs taken 30 days apart, showing erosive effect of mud circulation on diameter of hole in Dimmitt County, Texas.

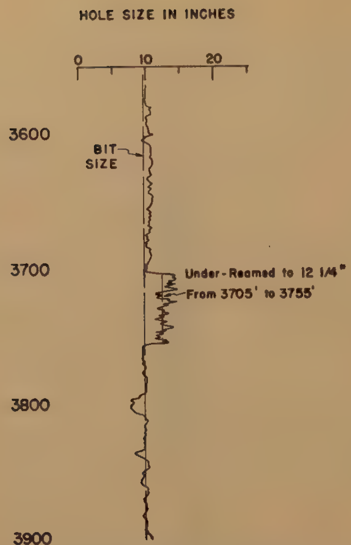


FIG. 10.—SHOWING PORTION OF HOLE DRILLED WITH 9⅞-INCH BIT AND UNDER-REAMED WITH 12¼-INCH REAMER, KERMAN FIELD, CALIFORNIA.

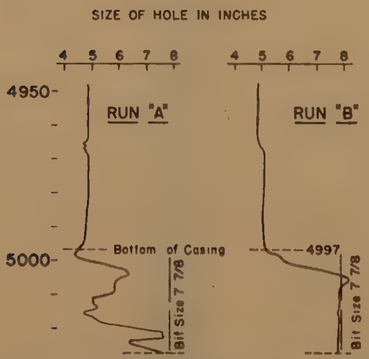


FIG. 11.—TWO CALIPER LOGS SHOWING PHYSICAL PROFILES OF PRODUCING FORMATION IN HOCKLEY COUNTY, TEXAS, BEFORE AND AFTER JETTING WITH ACID.

The first caliper log shows a sheath of cement covering most of the producing formation and the acid was applied to remove the sheath.

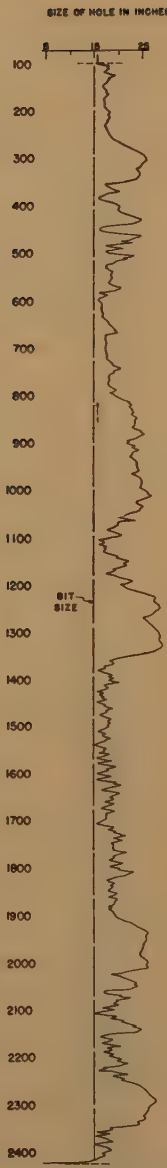


FIG. 12.—LOG FOR SELECTION OF PROPER PLACE TO SET SURFACE CASING IN PARADIS FIELD, SOUTHERN LOUISIANA.

It is obvious that surface casing should not be set above 1400 ft. nor between 1900 and 2350 ft. It also shows amount of cement necessary to fill the space behind the surface casing. The proper setting and cementing of the surface casing is tremendously important throughout the entire Gulf Coast as a protection against cratering when a well blows wild, owing to the many high-pressure gas sands in that area.

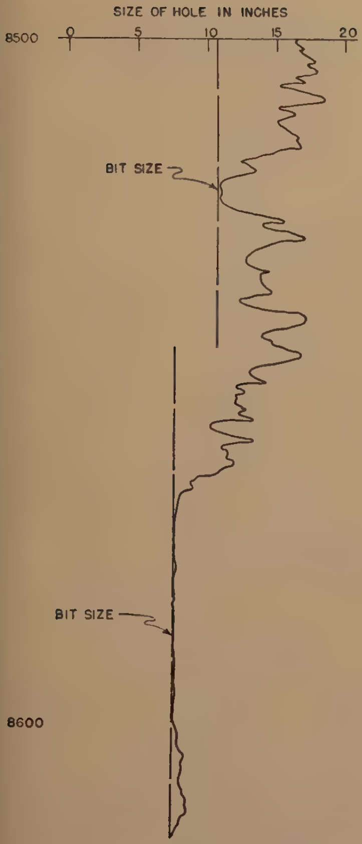
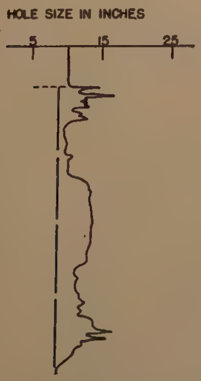


FIG. 13.—CALIPER LOG TAKEN TO DETERMINE AMOUNT OF CEMENT TO FILL SPACE BEHIND LINER, COALINGA, CALIFORNIA.



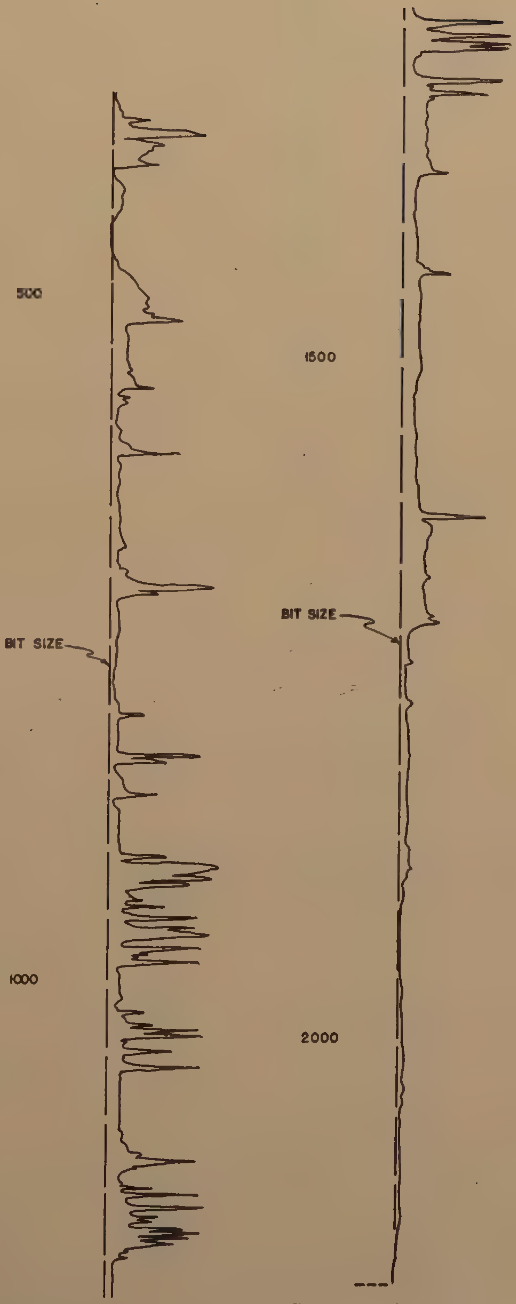


FIG. 14.—PHYSICAL PROFILE OF WILDCAT WELL DRILLED IN HOLT COUNTY, MISSOURI.

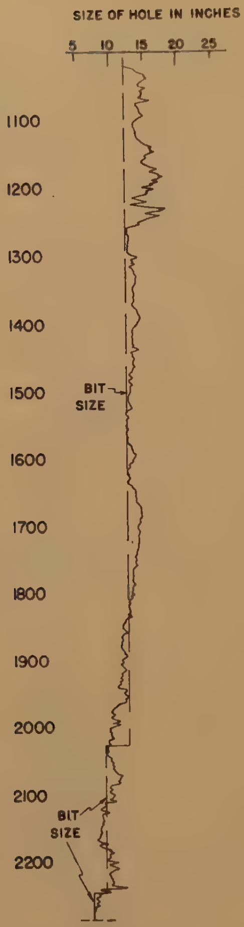


FIG. 15.—CALIPER LOG RUN TO STUDY "SHOULDERS" AT POINTS WHERE BIT SIZES WERE CHANGED, MOORE FIELD, TEXAS.

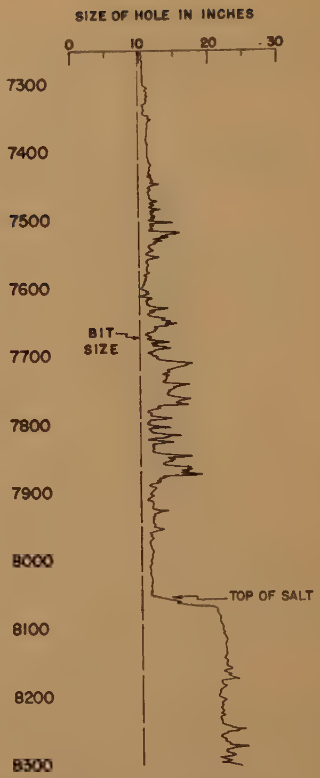


FIG. 16.—PHYSICAL PROFILE AT TOP OF SALT DOME, POTASH FIELD, SOUTHERN LOUISIANA.

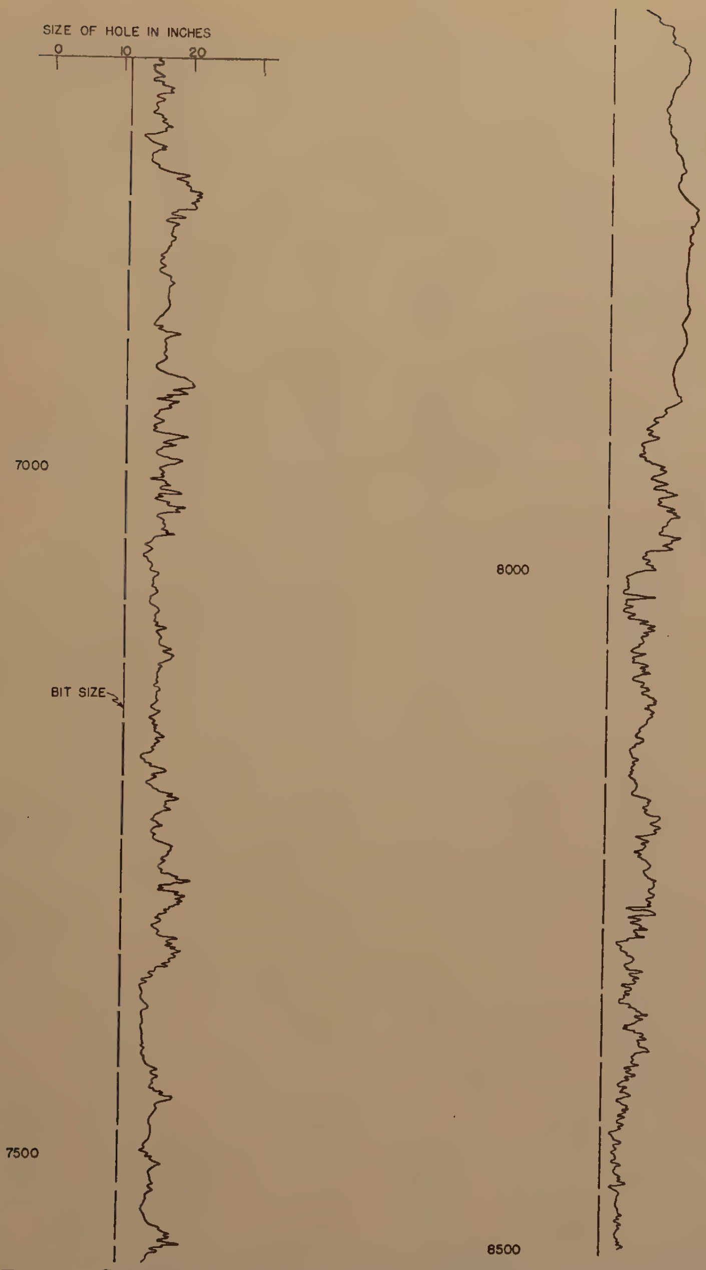


FIG. 17.—SHOWING EROSION IN DEEP WELL IN MIDWAY FIELD, CALIFORNIA.

Determination of Oil-well Capacities from Liquid-level Data

By Charles C. Rodd,* Junior Member A.I.M.E.

(New York Meeting, February 1942)

Abstract

Prior to 1938, proration procedure in Kansas required the physical testing of wells in order to set up a basis for allocating production. Subsequently the use of liquid-level data and bottom-hole pressure data was authorized on certain types of wells as a basis for calculating well capacities, thereby permitting wells to be tested at low rates and with small volumes of production.

This paper gives some attention to the equipment used for obtaining liquid-level data but in general it is devoted to the theoretical and physical factors involved in well testing by drawdown methods. These tests are divided into two classifications: (1) liquid-level data used directly to calculate capacities, and (2) liquid-level data and liquid-level measuring equipment used in connection with other data to determine bottom-hole pressure. Equations and calculations for both types are shown.

Well capacities calculated from fill-up data have not been used generally but offer a simple means of testing some wells. Theoretical factors and calculations for such tests are shown.

In the state of Kansas, proration laws required that the "ability of a well to produce" be given consideration in state allocation orders and for many years this was the only factor used in prorating the allowed oil. The "ability of a well to produce" was the quantity of oil that could be obtained from a well in a prescribed period, usually 24 hr. Early in the history of State-regulated proration, Kansas operators realized that, unless some restriction were placed upon equipment, the competition between producers to obtain large well "potentials" might result in a race to install the largest pumping equipment. Consequently, restrictions were placed upon the size of tubing and length of pump stroke that could be used in pumping wells during potential tests. Later, restrictions were placed also upon the size of tubing and chokes that could be used in flowing walls.

Despite the restriction setup, better pumping equipment was designed and installed, pumps were improved, and various devices were invoked to obtain high rates of production for short periods of time. By 1937 pumping cycles of forty to forty-five 54-in. strokes per minute were not uncommon, and numerous wells had produced at the rate of 3500 bbl. per day for short periods. Such production was far beyond any rate that could be long sustained. Equipment necessary to take "potentials" was several times larger than that needed for normal producing purposes, and repairs and replacements required by the high pumping speeds were excessive. Also, many operators suspected that the high rates of production maintained during "potential" tests were conducive to early water encroachment.

By 1938 large-scale physical testing of wells in Kansas ended, the use of the bottom-hole pressure gauge had become common, engineers and operators were becoming familiar with the term "productivity index," and bottom-hole pressure was being used as a factor in allocation in many areas. There were many drawbacks, however, to large-scale use of

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bottom-hole pressure gauges for determining well capacities, although numerous operators had used such equipment to obtain engineering data and, from a technical standpoint, had proved that the use of the equipment was feasible.

Fluid-level Measuring Equipment

In 1937, representatives of the Depthograph Company conducted experiments in Kansas with equipment that had been used in California to obtain data for determining well capacities. This equipment consisted essentially of: (1) a pressure chamber for releasing a charge of compressed air or gas into the annulus between tubing and casing, thereby setting up a wave front that would be reflected by the liquid surface as well as by fixed objects or reflectors in the well; (2) a diaphragm for detecting wave reflections; (3) apparatus for timing and recording the reflections. At that time measurements were dependent upon velocity calculations and correlation between these and fixed objects in the wells, such as tubing catchers and liner tops. Although the method had been quite successful in California it was not considered suitable for requirements in Kansas, for several reasons, among them the following:

1. Most wells in Kansas did not produce sufficient gas to maintain a homogeneous mass in the annulus above liquid level; velocity computations accordingly were complicated.
2. Few wells were equipped with tubing catchers or objects that could be used for correlation and in most wells liquid levels would have been above such objects had they been used.
3. Velocity computations were not considered accurate enough for official use by proration engineers.

It was known that reflections from tubing couplings could be obtained and as a result of the experiments in Kansas it was decided to make tubing the basis of measurement and modify equipment accordingly.

While the Depthograph Company was developing equipment to determine depths to liquid levels in oil wells, the International Geophysics Company of California developed an instrument—the Echometer—using a cartridge for setting up a wave front, a Tucker hot-wire microphone for detecting wave reflections, and an electrically controlled, direct-recording apparatus for obtaining a record of the wave reflection from tubing collars and liquid levels.

During the early part of 1938 a series of tests was conducted in Kansas with an Echometer. Although the tests brought out some of the deficiencies of equipment and methods, they established the practicability of using tubing collars as a basis of measurements, and the feasibility of testing Kansas Arbuckle dolomite wells by liquid-drawdown methods. In the latter part of 1938, the Kansas Corporation Commission gave official sanction to the use of Depthograph and Echometer equipment for testing certain types of wells. The use of bottom-hole pressure gauges also was approved and, later, a method, known as the "back-pressure method," for determining bottom-hole pressures from liquid levels and other data was included.

A third instrument, called the Sonic meter, for determining depths to liquid level in wells, was developed by the Gulf Oil Corporation. This instrument is electrically controlled; an ordinary blasting cap is used to initiate a wave front, a carbon-button microphone picks up reflections from tubing collars and the liquid level, and an oscillograph transmits the reflections to a camera recording device.

The development of liquid-level measuring equipment provides a ready means of measuring the liquid drawdown of a producing oil well. All of the instruments can, under proper conditions and within varying limits, determine the number of tubing couplings between the wellhead and the liquid level. Knowing the length of the tubing joints, it is then a simple matter to compute the distance to the level of liquid in the annulus. The relationship of these data to bottom-hole pressure and to well testing involves numerous factors.

THEORETICAL AND PHYSICAL FACTORS IN WELL TESTING

"Potentials" determined from bottom-hole pressure or liquid-level measurements are based on a straight-line relationship between pressure at the bottom of the well and the rate of production. Under certain conditions, liquid levels are proportional to pressures and the height of the liquid column may be substituted therefor. Well tests utilizing the relationship between pressure, or liquid level, and production rate eliminate the necessity for high rates of production. Tests taken in this manner have commonly been referred to as drawdown tests; that is, a drawing down of the pressure or liquid level by increasing the rate of production.

When the drawdown of pressure or liquid level is directly proportional to liquid production, the pressure-flow relationship may be expressed by a constant, commonly called the "productivity index," which is usually expressed in barrels per day per pound reduction in bottom-hole pressure, or barrels per day per foot drawdown.

In all but a few of the tests made in several thousand wells in Kansas the relationship between pressure and liquid production approximated a straight line between the limits of the production rates obtained. Numerous wells, with liquid capacities up to 2000 bbl. per day, have been tested to near capacity without deviating from the straight-line relationship, and tests made on wells producing as much as 2800 bbl. per day show no deviation (Fig. 1). Many wells have shown exceptionally large indicated capacities when drawdown data were extrapolated to zero bottom-hole pressure, and the accuracy of such indicated capacities has been questioned. Facilities for obtaining comparative data between drawdown and physical tests at rates above 3000 bbl. per day have not been available and for this reason, and others, it was considered advisable to set a maximum rating of 3000 bbl. for wells tested in Kansas by the drawdown method.

The straight-line relationship between pressure and producing rate may be expressed algebraically as follows:

$$C = \frac{Q}{P_r - P_p} \qquad [1]$$

where:

C = productivity index factor, bbl. fluid per day per lb. pressure drop.

P_r = static reservoir pressure, lb. per sq. in.

P_p = equilibrium bottom-hole pressure, lb. per sq. in. at stable flow rate Q.

Q = production rate, bbl. fluid per 24 hr.

Then:

$$Q_{\max} = CP_r \qquad [2]$$

Also:

$$C = \frac{Q_2 - Q_1}{P_1 - P_2} \qquad [3]$$

where:

Q_1 = oil-production rate, bbl. per 24 hr. at pressure P_1.

Q_2 = oil-production rate, bbl. per 24 hr. at pressure P_2.

From this equation the well capacity may be expressed as:

$$Q_{\max} = CP_1 + Q_1 = CP_2 + Q_2, \text{ etc.} \qquad [4]$$

Thus the factors needed for determining a well's capacity are the stable pressures at two producing rates, or the static pressure and stable pressure at one rate. For accuracy in testing, the former is preferred.

The components of bottom-hole pressure are: (1) the pressure due to the weight of the liquid column in the annulus, (2) the pressure due to the weight of gas in the annulus and (3) the pressure at the wellhead. Algebraically:

$$P_{bh} = hd + P_g + P_{ch} \qquad [5]$$

where

P_{bh} = bottom-hole pressure, lb. per sq. in.
h = height of liquid column, ft.
d = mean column weight of liquid, per ft. per sq. in.
P_g = pressure due to weight of gas column, lb. per sq. in.
P_{ch} = pressure at wellhead, lb. per sq. in.

TESTS FROM LIQUID LEVELS ONLY

In certain types of wells, notably Arbuckle dolomite wells in Kansas, operated under controlled condition, the density of the liquid column in the annulus between tubing and casing remains constant at varying rates of production. In such wells the change in pressure due to the weight of the gas column becomes negligible and the wells usually can be produced with zero casinghead pressure. Under such conditions, factors 2 and 3 in Eq. 5 may be neglected and bottom-hole pressure considered proportional to the height of the liquid column. Then:

$$C_1 = \frac{Q_1}{h_1 - h} \qquad [6]$$

C_1 = productivity index, bbl. per day per ft. drawdown.
Q_1 = production rate, bbl. liquid per day.
h = distance from wellhead to static liquid level, ft.
h_1 = distance from wellhead to liquid level at production rate Q_1, ft.

and

$$Q_{\max} = C_1(L - h) \qquad [7]$$

where

L = depth from wellhead to top of producing formation, ft.

The use of static liquid levels has not been found satisfactory in most places because many wells produce water and, under static conditions, water constitutes part of the liquid in the annulus preventing the density from remaining constant. Under producing conditions oil will tend to displace the water until a stable condition is reached and only oil remains in the annulus. The well must be tubed to the producing formation, of course, so that water will not accumulate below the tubing. When the static level is not used to determine a well's capacity to produce it becomes necessary to determine the liquid level in the well at two producing rates. Then:

$$C_1 = \frac{Q_2 - Q_1}{h_2 - h_1} \qquad [8]$$

where h_1 and h_2 are, respectively, the distances in ft. to the stable fluid levels at rates Q_1 and Q_2.

Then:

$$Q_{\max} = C_1(L - h_1) + Q_1 = C_1(L - h_2) + Q_2, \text{ etc.} \qquad [9]$$

In general, tests determined from liquid levels alone have been satisfactory on wells producing negligible quantities of gas where a liquid of constant density can be maintained in the annulus. Most Kansas Arbuckle wells produce no free gas and saturation pressures usually are less than 100 lb. per sq. in. As drawdown tests usually are taken at restricted rates, pressures seldom are reduced so much that appreciable gas is released into the annulus. In order to minimize difficulties met when making tests, Kansas regulations require that wells be tubed to bottom during official tests. Sample data and calculation for a test utilizing liquid-level data only are shown in Fig. 1.

BACK-PRESSURE METHOD

Wells producing considerable gas with the oil normally have a varying liquid density at different rates of production and normally are produced with some pressure at the wellhead. The height

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of the liquid column is seldom proportional to the bottom-hole pressure; consequently it cannot be used directly in computing the productivity index and consideration must be given to all the factors in Eq. 5, either by measuring the pressure directly with a bottom-hole pressure gauge or by determining the three constituents of bottom-hole pressure separately. These can be determined with reasonable accuracy from liquid-level and surface data by the back-pressure method.

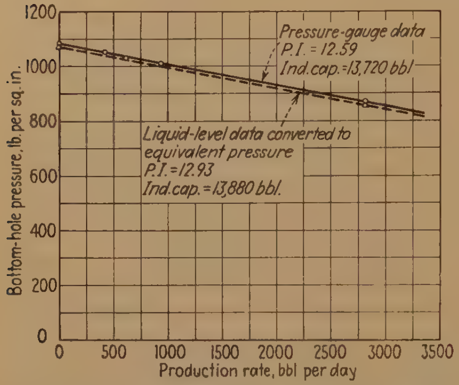

Fig. 1.—Comparative pressure-gauge and liquid-level test showing straight-line relationship to 2800 barrels.

Casing pressures can be obtained directly by use of suitable gauges. The determination of the pressure due to the weight of the gas column involves the measurement of the specific gravity of the gas by laboratory methods or, under certain conditions, empirically. One service company has developed an empirical method of determining specific gravity of the gas from the velocity of the wave used to determine the liquid level. The method has given satisfactory results under some conditions but may cause errors when it is necessary to use a compressor to maintain required pressures at the wellhead.

According to C. P. Walker, in U. S. Patent No. 2161733, knowing the pressure at the wellhead and the specific gravity and temperature of the gas in the annulus, the pressure at the liquid surface may be computed from the following equation:

$$\text{Log}_{10} P_b = \frac{SD}{122.82T} + \text{Log}_{10} P_t \quad [10]$$

where:

P_b = absolute pressure at bottom of gas column (top of liquid surface), lb. per sq. in.

S = specific gravity of gas.

D = length of gas column, ft.

T = mean temperature of gas, deg. F. abs.

P_t = casinghead pressure, lb. per sq. in. abs.

By control of the casing pressure, many wells can be produced without an appreciable quantity of liquid in the annulus. In such wells the effect of the liquid column becomes negligible and bottom-hole pressure may be determined from casing pressure and gas-column pressure. However, where it is impossible or impracticable to lower the liquid level to the pump or tubing perforations, consideration must be given to the height of the liquid in the annulus.

The determination of the pressure due to the weight of the liquid involves the establishment of two or more stable liquid levels, while maintaining a constant rate of production, by changing the casing pressure, either by permitting the well to build up pressure or by using a compressor. In this manner casing pressure is substituted for liquid pressure and, by dividing the change in pressure at the liquid surface by the change in liquid level, the column density may be determined. The average density will normally remain constant, if the production rate is constant. The total pressure of the liquid column may be computed by multiplying the column density by the height of the column above the desired datum, which must be at or above the tubing perforations. Any change in annular area may affect the column density of the liquid and a liner in the well may necessitate a separate determination for this section of the liquid column.

Adding the total liquid-column pressure to the pressure determined by Eq. 10 gives the bottom-hole pressure at that particular rate of production. When the bottom-hole pressure has been determined for two or more stable rates of production, the well capacity may be computed from Eq. 3 and Eq. 4 (Fig. 2).

Bottom-hole pressure tests usually require considerably more time than determinations of liquid levels. When bottom-hole pressure gauges are used it is difficult to determine when stabilization of flow has occurred and tests frequently are extended for some hours to assure reliable data. The use of bottom-hole pressure gauges in pumping wells requires pulling and rerunning rods, and occasionally tubing, before and after the tests, thereby involving considerable expense. Also, even under the most favorable conditions, the gauges are subject to damage from the shocks and vibration of a pumping well, and occasionally tests must be repeated.

Determination of bottom-hole pressure by the back-pressure method sometimes requires a compressor to maintain casing pressure, and when the well itself builds up pressure a regulating valve is necessary to maintain a constant pressure. The liquid-level measuring equipment used for back-pressure tests is essentially the same as for other tests except that it must be designed for high pressures.

Back-pressure and pressure-gauge tests require extreme care, both in obtaining data and in the interpretation and analysis of results. It has been found that, in certain types of wells, conditions arising through acidizing, and the attendant loading of the well, may temporarily affect the normal pressure drawdown, causing the test data to reflect an erroneous index.

TESTS FROM FILL-UP DATA

Liquid-level measuring equipment provides a means for obtaining fill-up data on a well. Although the method has not been widely used, and sometimes does not give satisfactory results, many wells that produce little gas and ordinarily can be tested by the liquid-drawdown method can also be tested by use of fill-up data.

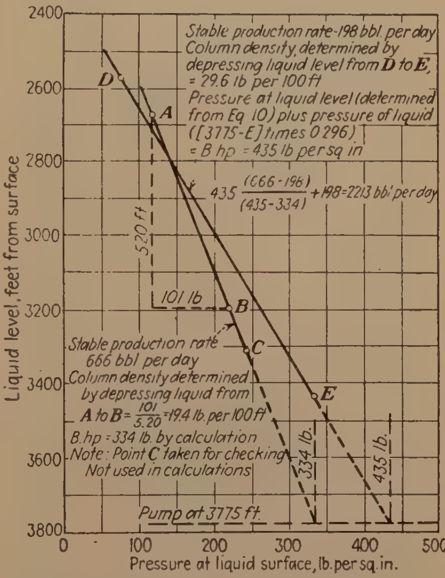

FIG. 2.—GRAPHIC ILLUSTRATION OF BACK-PRESSURE METHOD OF DETERMINING BOTTOM-HOLE PRESSURE.

The theoretical factors in the procedure for determining capacities from fill-up data were expressed by Muskat[5] in 1936 as follows:

$$Q = \frac{AH_s}{T} \log_e \frac{H_s - H_o}{H_s - H} \qquad [11]$$

where:

Q = well capacity, cu. ft. per min.
A = area of pipe or annulus, sq. ft.
T = time between H_o and H, min.
H_s = liquid height above formation at static level, ft.
H_o = liquid height above formation at zero time, ft.
H = liquid height above formation at time T, ft.

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[5] References are at the end of the paper.

From which it follows that:

$$C_x = \frac{A}{T} \log_e \frac{H_s - H_0}{H_s - H} \qquad [12]$$

C_x = constant equivalent to productivity index expressed in cubic feet per minute per foot drawdown.

To convert Eq. 12 into barrels per day per foot drawdown, the following factors must be introduced:

$$C_1 = \frac{7.48 \times 24 \times 60 \times 2.3}{42 \times 144} \times \frac{A}{T} \times \log_{10} \frac{H_s - H_0}{H_s - H} \qquad [13]$$

$$= \frac{4.1A}{T} \log_{10} \frac{H_s - H_0}{H_s - H} \qquad [14]$$

When A = area of pipe or annulus, sq. in.

C_1 = productivity index, bbl. fluid per day per ft. drawdown.

Then:

$$Q_{\max} = CH_s \qquad [15]$$

The determination of H_s—the static liquid level—can be made graphically by plotting $H_s - H$ against T (time in minutes) on semilogarithmic paper with $H_s - H$ on the log scale and time in minutes on the arithmetic scale. Different assumed values of H_s must be used until a straight-line relationship is obtained. The value of H_s that gives a straight line is, theoretically, the true static liquid level. In 60 per cent of the tests the straight-line relationship could be obtained and the calculated capacities closely approximated the capacities determined from pumping drawdown tests.

After a straight-line relationship is determined and the true value of H_s is obtained, the productivity index can be calculated by using any two points on the straight-line curve in Eq. 14. The productivity index can be determined also graphically by the following relationship:

$$C = \frac{1}{K} \times R \times A \times 4.1 \qquad [16]$$

When:

K = linear equivalent of one cycle on the log scale, expressed in minutes on the arithmetic scale.

R = slope of line.

Theoretically, liquid-level and time measurements sufficient to establish three points on the graph should be enough to determine the straight-line relationship and well capacity. However, it has been found desirable to obtain a comparatively large number of data to ensure maximum accuracy. Muskat has pointed out also that measurements should not be taken very close to the equilibrium value of H_s because small errors in H will give relatively large errors in the calculated value of C_1 or Q.

TABLE 1.—*Sample Data and Calculations, Official Kansas Drawdown Test*

LIQUID-LEVEL DATA ONLY

Production Data

Period	Hours Gauged	Depth to Liquid, Ft.	Production		24-hr. Rate, Bbl.
			Liquid, Bbl.	Water, Per Cent	
1	3	1,143	92.70	2	742
2	3	952	66.00		528
3	3	850	50.87		407

Well Data

Producing formation	Arbuckle dolomite
Well depth, ft.	3,284
Depth to top of producing formation, ft.	3,272
Casing size, inches o.d.	6
Depth to casing seat, ft.	3,271
Tubing size, ft.	3
Length of tubing, ft.	3,281
Number of tubing joints	105
Average length of tubing, ft.	30.9
Pump size, in.	$2\frac{3}{4}$
Depth of perforations, ft.	3,267–3,270

Calculations

Productivity index (low-high rates)

$$= \frac{742 - 407}{1143 - 850} = 1.143$$

$$\text{P.I. (low-intermediate rates)} = \frac{528 - 407}{952 - 850} = 1.186$$

$$\text{Average P.I.} = \frac{1.143 + 1.186}{2} = 1.165$$

Indicated liquid capacity

$= (3272 - 850) \times 1.165 + 407$

$= 3229$ bbl. per day

Well rating $= 3000 - $ (2 per cent of 3000)

$= 2940$ bbl. per day

Data on a fill-up test and the results of plotting the data on a semilogarithmic chart are shown in Fig. 3 and Table 2.

TABLE 2.—*Data and Caltulations, Fill-up Test*

Time	Depth to Liquid, Ft.	Liquid in Hole, Ft.	$H_s - H$		
			$H_s =$ 2790	$H_s =$ 2780	$H_s =$ 2786
0	722	2,581	209	199	205
3′–25″	702	2,601	189	179	185
6′–55″	681	2,622	168	158	164
11′–55″	659	2,644	146	136	142
16′–55″	640	2,663	127	117	123
26′–55″	609	2,694	96	86	92
41′–55″	576	2,727	63	53	59
56′–55″	556	2,747	43	33	39

Casing (7 in.) 24 lb. bottomed at 3303 ft.
Total depth, 3319 ft.
Tubing (3 in.) 9.30 lb. upset.
Area of annulus, 21.91 sq. in.
Calculations (H_s = 2786):

$$C = \frac{4.1 \times 21.91}{56.9} \text{Log}_{10} \frac{205}{39} = 1.138$$

Capacity = 1.138 × 2786 = 3170 bbl. per day
(Capacity determined by drawdown test was 3317 bbl. per day.)

RULES FOR OFFICIAL DRAWDOWN TESTS IN KANSAS

Fluid-level Tests

For the initial test of a well, liquid levels at three stable rates of production must be determined. The lowest rate of production must be at least 5 bbl. per hour; the intermediate and high rates must be at least 10 and 15 bbl. per hour, respectively. A spread of 10 bbl. per hour between high and low rates and 4 bbl. per hour between any two rates is required. (Exceptions are made for wells with capacities of less than 30 bbl. per hour.) Stabilization of the liquid level, within a limit of 5 ft. per hour, is required for each production rate and the well must be gauged for 3 hr. at each rate after stabilization is reached.

The productivity indices between the low and high rate and the low and intermediate rates are determined and the average of the two used to compute the capacity. (A retest may be required if the difference between the indices is more than 10 per cent of the higher one.) If the calculated capacity is less than 3000 bbl. of fluid per day the well is given a rating equal to the calculated capacity if no water was produced. If water was produced the rating is reduced by the percentage of water produced during the highest rate of production. If the calculated capacity is more than 3000 bbl. per day the well is given a rating of 3000 bbl. minus the percentage of water.

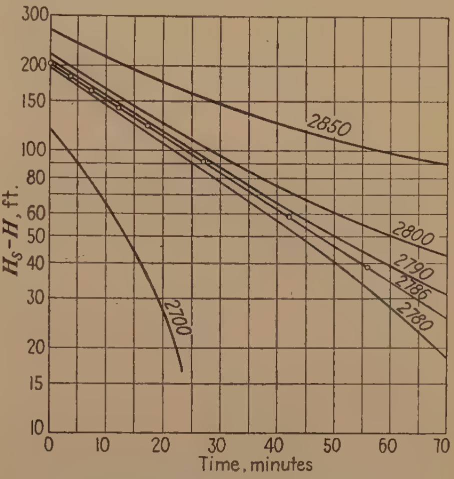

FIG. 3.—DETERMINATION OF STATIC LIQUID LEVEL (H_s) FROM FILL-UP DATA.

On subsequent tests only two rates of production are required. The high rate must be at least 15 bbl. per hour and a spread of 10 bbl. per hour between high and low rates is required. Other conditions are the same as for initial tests. All wells must be tubed to the top of the producing formation during official tests.

Bottom-hole Pressure Tests

Either a bottom-hole pressure gauge or the back-pressure method may be used. Pressures at two stable rates of production are required, and bottom-hole pressures must not vary more than 3 lb. per hour during each gauging period. The high rate must be at least 15 bbl. per hour and a spread of 10 bbl. per hour between high and low rates must be obtained. The high rate must be taken first and the stable period must be preceded by the production of 240 bbl. of liquid. Three-hour gauges at each rate are required. The maximum rating is 3000 bbl. per day with a deduction for water production on the same basis as for fluid-level tests. Wells must be tubed to the top of the producing formation.

Economics of Liquid-level Measurements

The advantages of conducting well tests without interfering with production are apparent, particularly where production is not restricted and down time means loss of income. Even where runs are restricted and down time does not involve loss of allowable, the expense of pulling rods and tubing is more than the cost of an extended study with liquid-level measuring equipment, which in Kansas has been largely in connection with official tests for allocation purposes. Prior to the use of drawdown tests, physical tests were required, which on most pumping wells necessitated the installation of large-capacity equipment costing from $7,000 to $12,000 per well, and required pumping the wells at rates that often were considered to be injurious to the reservoir. As well allowables were extremely low, the capacity of the equipment was not utilized, except for physical tests, for several years after installation. Since the adoption of drawdown tests, most operators are installing smaller equipment costing from $2,000 to $5,000 per well, and are pumping the wells at much lower rates than formerly.

The service cost of testing a pumping well varies from approximately $40, where liquid-level data alone are used, to approximately $140 for a back-pressure test requiring the use of a compressor. Labor cost varies from $10 to $25, depending on the type of test. The average cost of taking capacity physical tests, including labor and repairs to equipment, but excluding depreciation of pumping equipment, is approximately $125 per well.

Most flowing wells (and some pumping wells if properly equipped) can be tested more cheaply with bottom-hole pressure gauges than with liquid-level measuring equipment. Pressure gauges, however, are costly, and only a few operators own them.

Acknowledgments

The author wishes to acknowledge the cooperation of the Conservation Department of the Kansas Corporation Commission; The Depthograph Company, Mr. George Vaughn, Manager, Great Bend, Kansas; and The Halliburton Oil Well Cementing Company.

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Chapter II. Engineering Research

Water Influx into a Reservoir and Its Application to the Equation of Volumetric Balance

By William Hurst*

(New York Meeting, February 1942)

Abstract

This is a presentation of the diffusivity theory for the calculation of the water drive on an oil reservoir in which the history of reservoir pressure with time are the essential parameters for the determination of the rate and cumulative water encroachment into a field. The main body of the paper is essentially the application of the principles underlined here to actual field data. It consists of the work plots of the radial-flow case, and includes a discussion of an illustrated problem for which the water-drive calculations are treated in conjunction with the volumetric-balance equation. The appendix is a mathematical treatment of the linear, radial, and spherical cases of water influx into a reservoir.

Introduction

The evaluation of oil reserves and the prediction of pressure behavior with different rates of production are related to the volumetric balance of the fluids entering and leaving the space occupied by the oil and gas originally present in the formation; that is to say, important information can be gleaned from a volumetric study of the oil, gas, and water produced from a formation as it affects the extent of change in volume of oil zone, the gas cap, and the amount of water influx from the adjoining water sands.

It is not the purpose of this paper to enter into a discussion of the equation of volumetric balance, in which such pertinent information as subsurface sampling and the measurement of reservoir pressures play a predominant part, as this has been discussed in detail by others.[1,2] However, there is an inherent difficulty that has limited the general application of this equation to a study of oil reservoirs; that is, the insufficient knowledge of the analytics for expressing the water drive on a field as a function of reservoir pressure. This to a large degree has been overcome and it is the purpose of this paper to present this theory in such form as to be applicable for reservoir calculations.

Water Drive

If the amount of oil originally in place and the gas space are known, it is a relatively simple matter to determine, by the volumetric equation, the cumulative water influx into a reservoir from the adjoining water sands. Often, however, the oil reserve as well as water influx must be determined, and in order to be able to make this calculation it is essential to assign a mathematical relationship for the varying water term that is compatible with conditions known to exist in the formation and gives an accuracy acceptable for engineering calculations.

Various equations have been employed empirically by different investigators in making reservoir studies of water drive. One form used by Schilthuis[2] expresses the rate of water influx into a reservoir at any time as proportional to the pressure

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References are at the end of the paper.

difference between the original formation pressure and the pressure in the reservoir at the given time. Various other empirical relations have been used to take into account the effect of time on the water influx. With reference, however, to the application of empirical equations to water-drive calculations, it can be said that except in a few specific instances their general applications are limited.

The method described in this paper for the determination of water drive is based on the classical diffusivity equation. This equation was applied originally to the hydrodynamic problem by the author[3] in developing the transient conditions for the flow through a sand of a single-phase fluid whose compressibility is small or whose density varies exponentially with pressure. The derivation is developed by the application of Darcy's law for the flow of fluids through porous media to the equation of continuity. The final form, however, as applied to a slightly compressible fluid is given in vector notation, and expresses the divergence of the flow from an infinitesimal element of sand, as proportional to the pressure change per unit of time within the element itself. That is

$$\alpha^2 \nabla^2 P = \frac{\partial P}{\partial \theta} \qquad [1]$$

where ∇^2 is the Laplacian operator on pressure P in time θ, with the diffusivity constant equal to $\alpha^2 = K/\mu\phi c$ in which K is the permeability and ϕ the porosity of the sand, with μ the viscosity, and c the compressibility of the water. Thus a solution of Eq. 1 that can be applied to the formation, which also satisfies the boundary limits of the oil reservoir and water formation, is essentially a solution of the water drive. The analyses, given in the Appendix to this paper (p. 9) are the applications of Eq. 1 to the water drive on fields interpreted as linear, radial, and spherical influx of water into oil reservoirs.

This theory of water drive has been successfully applied by various investigators[4,5,6] to the study of water movements, as illustrated for the East Texas field. In the analysis of the problem the rate of oil production for this field was introduced in a solution of Eq. 1 to predict the pressure variations in the reservoir for different assumed rates. The reason it was possible to interpret the water influx into East Texas as proportional to the oil production lies in the characteristics of the field; at the existing reservoir pressures the oil is undersaturated with gas, and as there is no evidence of a gas drive, but only the presence of a water drive, the oil produced is replaced by a corresponding volume of water in the reservoir from the Woodbine formation. The solutions for water drive, as developed for East Texas, cannot be applied to a field that is subject to both a gas and water drive, as the application of the volumetric balance equation to the fluids in the reservoir shows that the water influx can be expressed only as a function of the reservoir pressure if the equation is to be solved explicitly for the oil originally in place.

It is the experience of the author that for the fields studied the radial flow case for water drive has proved sufficiently accurate for most engineering purposes, and for the remaining portion of the paper this solution only will be discussed. Nevertheless, it must be kept in mind that water drive can be effective not only as an influx of water from adjoining sands at the edge of a field but also as a rising table, and in general water drive should not necessarily be limited entirely to the radial-flow problem.

RADIAL FLOW

The physical interpretation of the boundary conditions for this case is that the oil field is concentric with the adjacent water formation, which is assumed to extend for large distances away from the field. Further, the water sand is considered to be initially saturated with water at the same pressure as the original reservoir pressure, but for increasing times pressure gradients are established from the edge of the oil reservoir back into the formation to approach the original pressure at some point removed from the field. These gradients, in turn, are subject to the variations of the field pressure, and this effect is introduced into the mathematics by superimposing a sequence of constant terminal pressure solutions, which essentially reproduces the pressure changes in the field. Thus by means of the calculus, and the application of Darcy's law at the periphery of the field, the water influx is determined as a function of reservoir pressure.

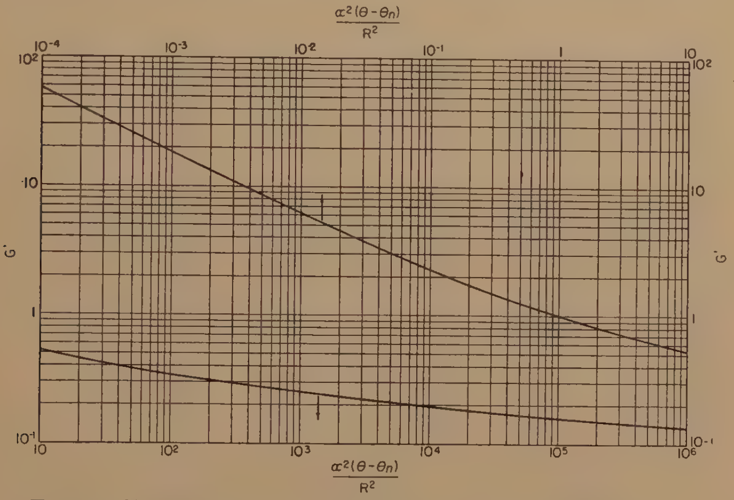

FIG. 1.—G^1 FUNCTION FOR CALCULATION OF RATE OF WATER INFLUX.

It has been observed that in the application of this theory to reservoir studies the physical values in the analytics, such as the diffusivity constant and the radius of the field, are not at all critical in evaluating the water influx. In several of the calculations the comparable term to these constants, namely α^2/R^2, was varied in the order of the probable error introduced in establishing this value, without materially affecting the calculated proportional influx of water for the entire history of the pressure surveys in the field. This range in scope for α^2/R^2 has also been observed in the application of this theory to flow tests on oil wells, in which the well is interpreted as an instantaneous point sink, analogous to the heat problem. It can be said from these observations, therefore, that the mathematics offers a certain amount of latitude in fixing the constants associated with water drive. However, what is most critical in these analyses is the history of the reservoir pressure as it varies with time.

It is derived in the Appendix that for the radial flow of water into a field, the rate of water influx into the oil reservoir at any time θ is expressed in barrels per day as

$$\frac{dZ}{d\theta} = -\frac{2\pi(144)K\sigma H}{5.62\mu}\int_0^\theta \frac{dP}{d\theta'}G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)d\theta' \quad [2]$$

and the cumulative water influx up to this time, expressed as barrels, is given by the relation

$$Z = -\frac{2\pi(144)K\sigma HR^2}{5.62\mu\alpha^2}\int_0^\theta \frac{dP}{d\theta'}G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)d\theta' \quad [3]$$

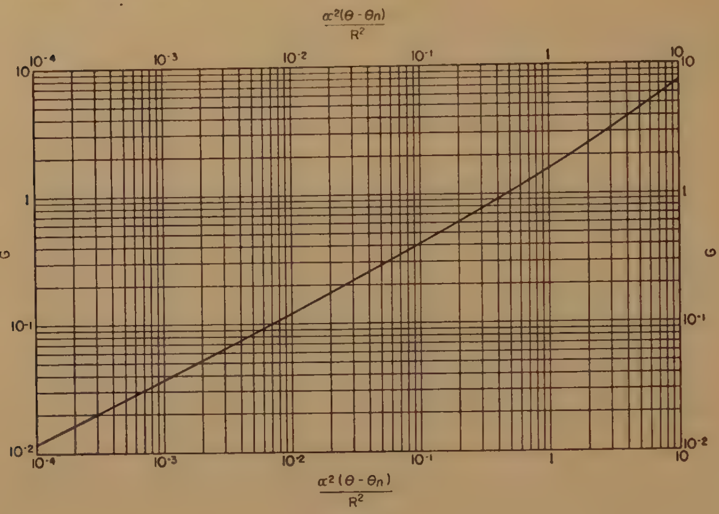

FIG. 2*a*.

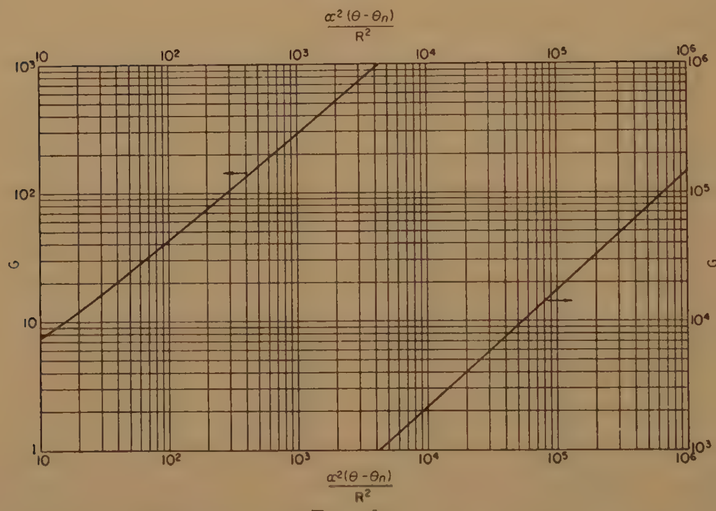

FIG. 2*b*.

FIG. 2.—*G* FUNCTION FOR CALCULATION OF CUMULATIVE WATER INFLUX.

The integrands in these equations are the products of the slopes of the reservoir pressure versus time curve for the field, multiplied by either $G'[\alpha^2(\theta - \theta')/R^2]$ or $G[\alpha^2(\theta - \theta')/R^2]$ which are given in Figs. 1, 2*a* and 2*b*, as functions of $\alpha^2(\theta - \theta')/R^2$. These pressure slopes are negative for decreasing reservoir pressures, and positive for increasing pressures. The definitions of the symbols and the units employed are given in the Nomenclature (p. 64).

An alternative form for expressing the cumulative water-influx equation is the relation

$$Z = \frac{2\pi(144)K\sigma H}{5.62\mu}\left[\int_0^{\theta_1} (P_R - P)G'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right) d\theta' + 2(P_R - P)R\sqrt{\frac{(\theta - \theta_1)}{\pi\alpha^2}}\right] \quad [4]$$

where reservoir pressure is explicitly

referred to as $(P_R - P)$, or as the difference between original reservoir pressure and pressure at time θ'. However, to satisfy the convergence of the integral the final pressure difference is taken as constant for the interval $\theta_1 \leq \theta' \leq \theta$ where $(\theta - \theta_1) \leq 0.001 R^2/\alpha^2$.

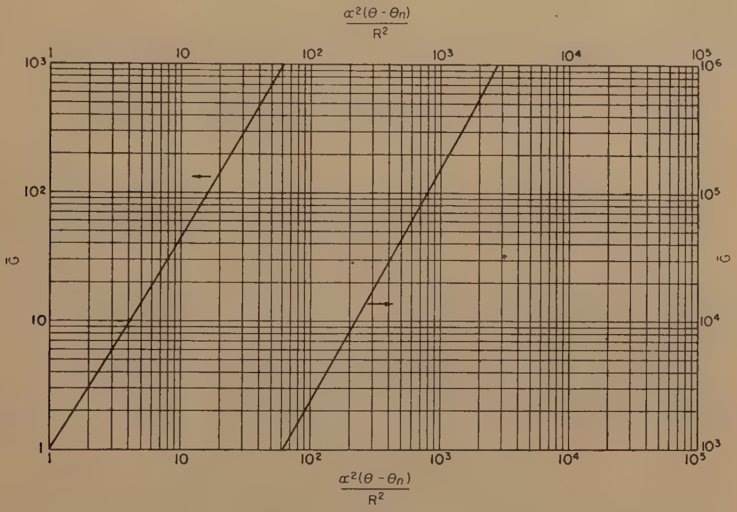

FIG. 3.—G FUNCTION FOR DETERMINATION OF INTEGRATED AVERAGE VALUE OF G.

With reference to Eqs. 2, 3 and 4, it can be stated definitely that none of these equations can establish the absolute water influx unless it is possible to fix the numerical coefficients associated with the integrals. From this remark, however, it must not be construed that these equations are limited; on the contrary, it is the proportional variations of the integrals as they fluctuate with time θ that are important in the calculations of the volumetric-balance equation, and for this reason Eqs. 3 and 4 should be regarded as

$$Z \sim \int_0^\theta \frac{dP}{d\theta'} G\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right) d\theta' \quad [3]$$

or

$$Z \sim \left[\int_0^{\theta_1} (P_R - P) G'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right) d\theta' + 2(P_R - P) R \sqrt{\frac{(\theta - \theta_1)}{\pi \alpha^2}}\right] \quad [4]$$

Thus in the determination of the absolute water influx into a field, the coefficient associated with either of these equations is established algebraically, along with the quantity of oil originally in place, by a solution of the volumetric balance equation for the fluids in the oil reservoir.

Eq. 3 is particularly suited to determination of the cumulative water influx into a reservoir, where the reservoir pressure-time curve may be represented as a series of straight lines (Fig. 4). If the pressure-time relation is a smooth curve, there is no alternative but to resort to a graphical integration. Thus if the pressure variation in a reservoir is represented in "broken-line" fashion, with the pressure at different times as P_R, P_1, P_2 at time zero, θ_1 and θ_2, etc., the pressure-time slopes are the following:

$$-\frac{dP}{d\theta'} = \frac{(P_R - P_1)}{\theta_1}; \qquad 0 \leq \theta' \leq \theta_1$$

$$-\frac{dP}{d\theta'} = \frac{(P_1 - P_2)}{(\theta_2 - \theta_1)}; \qquad \theta_1 \leq \theta' \leq \theta_2$$

$$-\frac{dP}{d\theta'} = \frac{(P_2 - P_3)}{(\theta_3 - \theta_2)}; \qquad \theta_2 \leq \theta' \leq \theta_3$$

$$\cdots\cdots\cdots\cdots\cdots\cdots$$

$$-\frac{dP}{d\theta'} = \frac{(P_{n-1} - P)}{(\theta - \theta_{n-1})}; \qquad \theta_{n-1} \leq \theta' \leq \theta$$

This means that between the pressure surveys the slope of a line is fixed, therefore Eq. 3 can be expressed as

$$Z = \frac{2\pi(144)K\sigma HR^2}{5.62\mu\alpha^2}\left[\frac{(P_R - P_1)}{\theta_1}\int_0^{\theta_1} G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)d\theta' + \frac{(P_1 - P_2)}{(\theta_2 - \theta_1)}\int_{\theta_1}^{\theta_2} G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)d\theta' + \frac{(P_2 - P_3)}{(\theta_3 - \theta_2)}\int_{\theta_2}^{\theta_3} G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)d\theta' + \cdots + \frac{(P_{n-1} - P)}{(\theta - \theta_{n-1})}\int_{\theta_{n-1}}^{\theta} G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)d\theta'\right] \qquad [5]$$

However, defining $\bar{G}(n)$ by the relationship

$$\bar{G}(n) = \int_0^n G(n)dn$$

which is plotted as $\bar{G}(\alpha^2(\theta - \theta')/R^2)$ versus $\alpha^2(\theta - \theta')/R^2$ in Fig. 3, the cumulative water equation may be expressed as

$$Z = \frac{2\pi(144)K\sigma HR^2}{5.62\mu\alpha^2}\left\{(P_R - P_1)\left[\frac{\bar{G}(\alpha^2\theta/R^2) - \bar{G}(\alpha^2(\theta-\theta_1)/R^2)}{\alpha^2\theta_1/R^2}\right] + (P_1 - P_2)\left[\frac{\bar{G}(\alpha^2(\theta-\theta_1)/R^2) - \bar{G}(\alpha^2(\theta-\theta_2)/R^2)}{\alpha^2(\theta_2-\theta_1)/R^2}\right] + (P_2 - P_3)\left[\frac{\bar{G}(\alpha^2(\theta-\theta_2)/R^2) - \bar{G}(\alpha^2(\theta-\theta_3)/R^2)}{\alpha^2(\theta_3-\theta_2)/R^2}\right] + \cdots + (P_{n-1} - P)\left[\frac{\bar{G}(\alpha^2(\theta-\theta_{n-1})/R^2}{\alpha^2(\theta-\theta_{n-1})/R^2}\right]\right\} \qquad [6]$$

where the terms inside the brackets are the integrated average values for G over the time limits referred to in the equation.

In a similar manner the rate equation can be established in terms of G functions, which are the integrated averages for the G' functions over the corresponding time limits. It must be pointed out, however, that in the series expansion the water-rate equation is most sensitive to the pressure-time variation of the final surveys, whereas in the cumulative equation this applies only to the earlier pressure surveys.

Illustrative Calculation, Radial Flow

In this illustrative calculation for a Gulf Coast field, the purpose is to show the application of the theory to the determination of the cumulative water influx for the "broken-line" pressure variation, and also to show the close agreement between the calculated relative water influx at various times and the corresponding cumulative water as determined from a volumetric balance on the field. The case illustrated is that for the radial flow of water, and is an application of Eq. 6.

The physical constants for the determination of the diffusivity factor for the field, as established from core analysis and the viscosity of the salt water at the reservoir temperature, are given as follows:

K/μ = 200 md., or 200/22,700 = 0.00882 cu. ft./day/sq. ft./lb./sq. ft./ft.

ϕ = 0.28, and with $c = 2.5(10)^{-8}$ cu. ft./cu. ft./lb./sq. ft. for water.

Thus

$$\alpha^2 = K/\mu\phi c = \frac{(0.00882)}{(0.28)(2.5)(10)^{-8}} = 1.260(10)^6 \text{ sq. ft. per day.}$$

The radius of this field is approximately R = 7850 ft., so

$$\alpha^2/R^2 = \frac{1.260(10)^6}{6.180(10)^7} = 2.04(10)^{-2} \text{ per day.}$$

Shown in Fig. 4 and listed in Table 1 are the data on the reservoir pressure against time for the field, corrected to a fixed subsurface depth. Also listed in the table is the time argument $\alpha^2\theta_n/R^2$ for each pressure survey. In Table 2 is given a sample calculation of the proportional between the actual and calculated water influx as represented by the ratio Z/Z_{1766}, which is arbitrarily chosen to represent the proportional variation of the water cumulative water influx for 1645 days of the production life of the field, employing Eq. 6 and the corresponding plot for the $\bar{G}$ function. Finally, in Table 3 are listed the calculated values for all 10 surveys against actual values for water influx, which were determined from the volumetric-balance equation using the geological estimate of the oil originally in place.

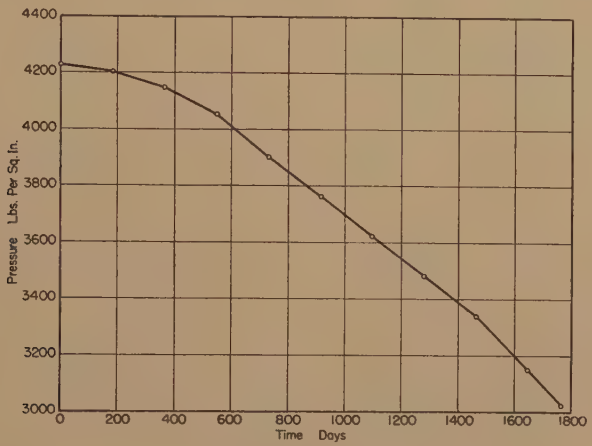

FIG. 4.—RESERVOIR PRESSURE VS. TIME.

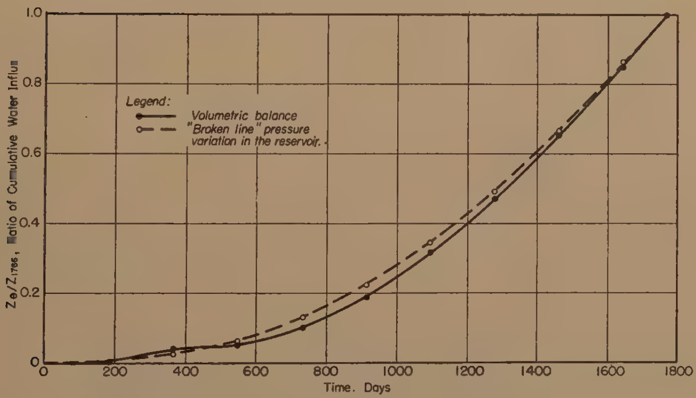

FIG. 5.—CUMULATIVE WATER INFLUX VS. TIME.

It is observed that in Table 2, and also in Fig. 5, there is fairly good agreement drive. This is true for the last eight surveys, although the first two are considerably off. However, this should not be construed as an inaccuracy in the theory of water drive for early times, but rather as a limitation of the volumetric-balance equation, which is fairly insensitive to small pressure drops from the original reservoir pressure. The numerical coefficient of Eq. 6, which is determined from the volumetric and calculated water influx given in Table 2, is also listed. The constancy of this coefficient is a further check on the two sets of data. Thus for the last eight surveys the numerical average of this coefficient is 896 with a standard deviation from the average of only 8 per cent.

TABLE 1.—*Pressure-time Data*

θ_n, Days	$\alpha^2\theta/R^2$	P_n, Reservoir Pressure, Lb. per Sq. In.	$(P_n - P_{n+1})$, Lb. per Sq. In.
0	0	4,225	25
184	3.75	4,200	55
366	7.47	4,145	95
550	11.22	4,050	150
731	14.91	3,900	140
915	18.67	3,760	140
1,096	22.36	3,620	140
1,280	26.11	3,480	140
1,461	29.80	3,340	190
1,645	33.56	3,150	127
1,766	36.03	3,023	

In all fields where this theory has been applied, the calculated water-drive values give results that agree with the proportional variation of the comparable term in the volumetric-balance equation.

NOMENCLATURE

$dZ/d\theta$, rate of water influx into the reservoir, bbl. per day.
Z, total water influx at any time, bbl.
K, permeability relative to one centipoise, cu. ft./day/sq. ft./lb./sq. ft./ft.
c, compressibility, cu. ft./cu. ft./lb./sq. ft.
ϕ, porosity, fraction.
α^2, diffusivity, sq. ft. per day.
R, radius of reservoir, ft.
H, sand thickness, ft.
P, reservoir pressure, lb. per sq. in.
θ, time, days.
σ, fraction of perimeter of field exposed to water drive.
μ, viscosity of water in formation, centipoise.

TABLE 2.—*Sample Cumulative Water-influx Calculation*
TIME, θ = 1645 DAYS

$\alpha^2\theta_n/R^2$	$\alpha^2(\theta - \theta_n)/R^2$	$\alpha^2(\theta_{n+1} - \theta_n)/R^2$	$[\bar{G}(\alpha^2(\theta - \theta_n)/R^2) - \bar{G}(\alpha^2(\theta - \theta_{n+1})/R^2)]$	$\frac{[\bar{G}(\alpha^2(\theta - \theta_n)/R^2) - \bar{G}(\alpha^2(\theta - \theta_{n+1})/R^2)]}{\alpha^2(\theta_{n+1} - \theta_n)/R^2} \times (P_n - P_{n+1})$
0.0	33.56	3.75	65	(17.35) × (25) = 433
3.75	29.81	3.72	55	(14.80) × (55) = 814
7.47	26.09	3.75	53	(14.15) × (95) = 1,348
11.22	22.34	3.69	47	(12.71) × (150) = 1,905
14.91	18.65	3.76	40	(10.62) × (140) = 1,490
18.67	14.89	3.69	33	(8.95) × (140) = 1,252
22.36	11.20	3.75	25.2	(6.72) × (140) = 940
26.11	7.45	3.69	18.4	(4.98) × (140) = 698
29.80	3.76	3.76	8.4	(2.23) × (190) = 424
33.56				
				$Z_{1645} \sim 9{,}304$

TABLE 3.—*Comparison of Actual and Calculated Cumulative Water Influx*

θ_n, Days	Volumetric Balance		Calculated		$\frac{2\pi(144)K\sigma HR^2}{5.62\mu\alpha^2}$
	Z_{θ_n}, Bbl.	Z_{θ_n}/Z_{1766}	Z_{θ_n}	Z_{θ_n}/Z_{1766}	
0	0	0	0	0	
184	1,100	0.001	56	0.0052	20
366	433,000	0.0408	247	0.0229	1,753
550	531,000	0.0501	657	0.0608	808
731	1,120,000	0.106	1,403	0.130	798
915	2,000,000	0.189	2,449	0.227	817
1,096	3,320,000	0.313	3,737	0.346	888
1,280	4,980,000	0.470	5,295	0.490	941
1,461	6,900,000	0.651	7,142	0.661	966
1,645	9,000,000	0.848	9,304	0.861	967
1,766	10,600,000	1.000	10,808	1.000	981

APPENDIX

It has been shown in this paper that an interpretation for water drive can be deduced from the movement of slightly compressible fluid flowing through a porous medium in an unsteady state. This is expressed by Eq. 1, which is applicable to the flow of fluid in a sand body parallel to the earth's surface, and therefore independent of gravitational effects. Where the water drive is not restricted to a horizontal plane the velocity potential or driving force, as applied to Darcy's equation, is $\Phi = P \pm g\gamma x$, or reservoir pressure plus or minus the hydrostatic head of fluid, depending on the direction of flow relative to a given datum plan; with g the acceleration of gravity, γ the density of the fluid, and x the vertical component of the fluid head. Therefore, where the water drive is influenced by gravity the comparable form to Eq. 1 is the relation

$$\alpha^2\nabla^2\Phi \cong \frac{\partial\Phi}{\partial\theta} \qquad [1]$$

which is sustained for the small compressibility for water, as

$$\frac{\partial\Phi}{\partial\theta} = \frac{\partial P}{\partial\theta} \pm gx\frac{\partial\gamma}{\partial\theta} \cong \frac{\partial P}{\partial\theta}$$

It must be mentioned, however, that Φ or P can be interchanged, because what is derived in these analyses is the variation of water influx as a function of Φ, referred to some given datum point or plane in the reservoir, and therefore $\Delta\Phi = \Delta P$ for the same subsurface depth. Further, the limits defined for P in the following analyses apply also to Φ for nonhorizontal formations.

A solution of the equation in which pressure or velocity potential is expressed as a function of distance from the field and time is essentially a solution of the problem for water influx, provided the boundary limits of the problem are met. These limits are: (1) that initially the reservoir pressure in the water sand is fixed and uniform for large distances away from the edge of the field proper, and (2) that the influx of water is reflected by the actual variations of the pressure in the oil reservoir itself.

It must be understood, though, that the mathematical treatment of the problem cannot be regarded as absolute; rather, it is empirical, because of the fact that it has been necessary to assume the sand to be of uniform permeability throughout. An explicit analysis of the problem in which the sand is irregular would be difficult, if at all soluble, and there would not be sufficient geological data available to justify its usage. However, the good agreement between the relative water influx at various times as calculated from field data and that determined from the theory suggests the applicability of this analysis for the determination of the extent of water drive in an oil reservoir.

There are two possible ways of treating these problems to include the pressure variation in the reservoir: (1) Duhamel's principle[7] and (2) one determined from an extended treatment by the present author of an analysis in radial flow by Lloyd P. Smith.[8] In either method it is necessary to have the explicit solution for the constant terminal pressure case. That is to say, the analysis must be known for the condition in which the initial reservoir pressure in the water sand is fixed and uniform for large distances from the edge of the field, but for the duration of flow the pressure at the field's edge is held constant at a value fixed by the analytics.

In the final analysis, Duhamel's principle and the method presented in this report are identical. However, a derivation of Duhamel's principle would require a somewhat abstract mathematical treatment, whereas the second method offers an analysis based on the physics of the problem, which should therefore prove to be more conducive to an understanding of the solution.

Radial Flow

Lloyd P. Smith[8] developed an analysis for the determination of the heat influx into a mine shaft. The mathematics involved a treatment of contour integrals to the solution of a Green's function in a concentric radial system of infinite extent. To facilitate the solution of the problem, he introduced the temperature variation in the mine as a "step-fashion" relationship to determine the amount of heat transmitted from the formation. The similarity, however, of the mathematics for the flow of heat and the flow of slightly compressible fluids, such as water, suggested to this author a comparable method to determine the extent of water drive in an oil field in which the controlling factor is the reservoir pressure. The derivation, as given here, treats this independent variable as any general pressure change in the reservoir, as compared with the somewhat restricted "step-fashion" variation indicated in Smith's work. This is effected by superimposing a sequence of constant terminal pressure solutions, which in effect reproduces the pressure variations at the field's edge.

To understand this derivation it is necessary to develop the following mathematics: Thus, if it is assumed that the pressure, at the periphery of the field next to the water sand, varies in "step-fashion" with time, then symbolically it can be written that

$$\begin{array}{ll} P = P_R; & \theta = 0 \\ P = P_1; & 0 \leq \theta \leq \theta_1 \\ P = P_2; & \theta_1 \leq \theta \leq \theta_2 \\ \cdots & \cdots \\ P = P_n; & \theta_{n-1} \leq \theta \leq \theta_n \end{array} \qquad [2]$$

with θ_n the final time. This means that at zero time the pressure drops from the initial reservoir pressure P_R to a lower pressure P_1, which remains constant from zero time to some given time θ_1, where again the pressure is lowered from P_1 to P_2, and this pressure in turn remains constant from time θ_1 to θ_2. This process is continued as a sequence of constant pressure plateaus to include the final pressure at time θ.

Thus, if a point in this history of pressure variation is isolated, say for the instant of zero time, when the pressure suddenly changes from P_R to P_1, and it is assumed that the latter pressure remains constant for the entire duration of flow, then if the constant terminal pressure solution of the radial equation is known, and expressed by $F(r, \theta)$, which gives a pressure value of unity for r greater than R, the radius of the oil reservoir, and zero at all times for $r = R$, the value for pressure in the water sand at a distance r from the center of the field in time θ is expressed by

$$\Delta P(r, \theta) = (P_R - P_1)F(r, \theta)$$

Actually the influence of pressure drop $(P_R - P_1)$ in the oil reservoir on the water sand is not self-sustained, since P does not remain constant for the entire period of production, but is followed by the sequence of pressure "steps," Eq. 2. To reproduce this effect, then, each sudden change in pressure in the reservoir can be treated as an individual constant terminal pressure solution, entirely separate from the others, but which becomes effective only at the instant that the pressure change occurs in the reservoir. The net effect, however, of the "step-fashion" pressure variation in the oil reservoir on the water sand is the superimposing of all these individual solutions, one on the other, to give the equation for the pressure at the distance r from the center of the field in time θ, or

$$\begin{aligned} P(r, \theta) = {} & (P_R - P_1)F(r, \theta) \\ & + (P_1 - P_2)F(r, \theta - \theta_1) \\ & + (P_2 - P_3)F(r, \theta - \theta_2) \\ & + \cdots + (P_{n-1} - P_n)F(r, \theta - \theta_{n-1}) \end{aligned} \qquad [3]$$

where $F(r, \theta - \theta_n)$ is a constant terminal pressure solution referred to a zero time, θ_n.

The rate of water influx into the reservoir is established by Darcy's law for the flow of fluids. This law, as applied to a slightly compressible fluid, is the basis for the derivation of Eq. 1 in the equation of the continuity of flow. The law, stated briefly, is that the linear velocity of flow of a fluid along its stream line is directly proportional to the pressure drop per unit length of flow. Therefore, the rate of water movement into the reservoir, given as barrels per day, is expressed as

$$\frac{dZ}{d\theta} = \frac{(144)K\sigma A}{5.62\mu}\left(\frac{\partial P}{\partial r}\right)_{r=R} \qquad [4]$$

using the engineering units listed in the Nomenclature of this paper, with K the normal permeability of the water formation, μ the viscosity of the water, σ the fraction of the perimeter of the field exposed to water drive, and $A = 2\pi RH$ the peripheral area of the reservoir, or

$$\frac{dZ}{d\theta} = \frac{2\pi(144)K\sigma H}{5.62\mu}\left(\frac{r\partial P}{\partial r}\right)_{r=R} \qquad [5]$$

with H the thickness of the sand.

For the purpose of simplifying the calculus involved in applying Eq. 5, the differentiation of $F(r, \theta)$ may be defined by the expression

$$\left(\frac{r\partial F(r,\theta)}{\partial r}\right)_{r=R} = G'\left(\frac{\alpha^2\theta}{R^2}\right) \qquad [6]$$

where $G'(\alpha^2\theta/R^2)$ is arbitrarily taken as a function that is a first-order differential of $G(\alpha^2\theta/R^2)$ with respect to the argument $\alpha^2\theta/R^2$. Therefore, by means of Eqs. 3 and 5,

$$\begin{aligned}\frac{dZ}{d\theta} = \frac{2\pi(144)K\sigma H}{5.62\mu}\Bigg[&(P_R - P_1)G'\left(\frac{\alpha^2\theta}{R^2}\right)\\ &+ (P_1 - P_2)G'\left(\frac{\alpha^2(\theta-\theta_1)}{R^2}\right)\\ &+ (P_2 - P_3)G'\left(\frac{\alpha^2(\theta-\theta_2)}{R^2}\right) + \cdots\\ &+ (P_{n-1} - P_n)G'\left(\frac{\alpha^2(\theta-\theta_{n-1})}{R^2}\right)\Bigg]\end{aligned} \qquad [7]$$

This equation is a sequence of fluid-rate terms of the constant terminal pressure case, with each term referred to its initial time of corresponding pressure change in the reservoir. The comparable values to G' were determined by the author in an earlier study of the constant terminal pressure case.[3] The analytics of this work is essentially that of Eq. 7, for which P_1 is held constant for the entire period of production, or

$$G'\left(\frac{\alpha^2\theta}{R^2}\right) = \frac{5.62\mu}{2\pi(144)K\sigma H(P_R - P_1)}\frac{dZ}{d\theta}$$

The corresponding term to G' in the paper cited[3] is computed for a large range of time arguments. Its transformation to this analysis is given as follows: In Fig. 4 of the paper cited[3] is given a family of curves in which the branch curves correspond to closed-in reservoirs of varying dimensions, but the envelope of these curves is the rate-time relationship of the constant terminal pressure case for the infinite concentric radial system. The rate terms q_R of Fig. 4 and $dZ/d\theta$ of this analysis are interchangeable, and as this theory applies to a slightly compressible fluid,

$$\begin{aligned}G'\left(\frac{\alpha^2\theta}{R^2}\right) &= \frac{1}{2\pi}\left[\frac{q_R c}{KH(1 - \epsilon^{-c(P_R - P_W)})}\right]\\ &\cong \frac{q_R}{2\pi KH(P_R - P_W)}\end{aligned}$$

as both sides of the equation are dimensionless. Thus $\alpha^2\theta/R^2$ is the abscissas of Fig. 4, and the reciprocal of G' is equal to 2π times the ordinate of the main stem of these curves.

The curves of Fig. 4 of the paper are likewise reproduced in Fig. 1 of a paper by Moore, Schilthuis and Hurst,[9] and the transformation for G' is expressed by the equation

$$\begin{aligned}G'\left(\frac{\alpha^2\theta}{R^2}\right) &= \frac{5.62q_R}{2\pi KH(1 - \epsilon^{-144c(P_R - P_W)})}\\ &= \frac{q_R}{1.12KH(1 - \epsilon^{-144c(P_R - P_W)})}\end{aligned}$$

in which the conversion factor 5.62 has been introduced to convert barrels per day to cubic feet per day.

The values of $G'(\alpha^2(\theta - \theta_n)/R^2)$ versus $\alpha^2(\theta - \theta_n)/R^2$ are given in Fig. 1 for time arguments from $\alpha^2\theta/R^2 = 0.0001$ to 1,000,000.

The cumulative water influx into the reservoir is established by the integration of Eq. 7 with time. In carrying out this step, however, it is necessary to take into account the fact that each term in this equation is dependent on the relative time that its pressure drop is effective in the history of the pressure change in the reservoir. The integration, then, of Eq. 7 is expressed as

$$\begin{aligned} Z = \frac{2\pi(144)K\sigma H}{5.62\mu}\Bigg[&(P_R - P_1)\int_0^\theta G'\left(\frac{\alpha^2\theta}{R^2}\right)d\theta + (P_1 - P_2)\int_{\theta_1}^\theta G'\left(\frac{\alpha^2(\theta - \theta_1)}{R^2}\right)d\theta \\ &+ (P_2 - P_3)\int_{\theta_2}^\theta G'\left(\frac{\alpha^2(\theta - \theta_2)}{R^2}\right)d\theta + \cdots \\ &+ (P_{n-1} - P_n)\int_{\theta_{n-1}}^\theta G'\left(\frac{\alpha^2(\theta - \theta_{n-1})}{R^2}\right)d\theta\Bigg] \end{aligned}$$

Therefore, by the relationship

$$\int_0^\theta G'\left(\frac{\alpha^2\theta}{R^2}\right)d\theta = \frac{R^2}{\alpha^2}G\left(\frac{\alpha^2\theta}{R^2}\right)$$

this equation becomes

$$\begin{aligned} Z = \frac{2\pi(144)K\sigma H R^2}{5.62\mu\alpha^2}\Bigg[&(P_R - P_1)G\left(\frac{\alpha^2\theta}{R^2}\right) + (P_1 - P_2)G\left(\frac{\alpha^2(\theta - \theta_1)}{R^2}\right) \\ &+ (P_2 - P_3)G\left(\frac{\alpha^2(\theta - \theta_2)}{R^2}\right) + \cdots + (P_{n-1} - P_n)G\left(\frac{\alpha^2(\theta - \theta_{n-1})}{R^2}\right)\Bigg] \end{aligned} \qquad [8]$$

Thus, it is also observed that the terms of this series form a sequence of cumulative water-influx values of the constant terminal pressure case, and each occurs in the order as the pressure change in the reservoir is effected in the "step-fashion" variation.

The integrations indicated in Eq. 8 are likewise developed in the earlier paper,[3] for which the corresponding values to G are computed for a large time range. Thus for a constant pressure P_1 in the reservoir, Eq. 8 reduces to

$$G\left(\frac{\alpha^2\theta}{R^2}\right) = \frac{5.62Z}{2\pi(144)H\sigma R^2\phi c(P_R - P_1)}$$

with $\alpha^2 = K/\mu\phi c$ and the corresponding relation in the paper (Fig. 5) is given by

$$G\left(\frac{\alpha^2\theta}{R}\right) = \frac{Q_R}{2\pi H\phi a^2(1 - \epsilon^{-c(P_R - P_W)})} \cong \frac{Q_R}{2\pi H\phi a^2 c(P_R - P_W)}$$

where Q_R and Z as well as a^2 and R^2 are interchangeable, with $\sigma = 1$. The expression for G, then, is equal to the ordinate of the main stem of the family of curves divided by 2π. These values are given in Figs. 2*a* and 2*b* of this paper.

In this analysis, the influx of water into the reservoir from the adjacent water formation has been restricted to the "step-fashion" pressure variation in the field. That the pressure does not necessarily vary in this manner is evident, since a host of factors influence the pressure change in the reservoir. For this reason, therefore, it is necessary to develop the analytics further to include any general pressure variation as it affects the extent of water drive on the field.

In order to accomplish this, it is assumed that the pressure in the reservoir varies in "step-fashion," Eq. 2, but that each pressure plateau is of extremely short duration, such that if $\delta\theta$ is the length of time for each plateau, there will be $\theta/\delta\theta$ or n "steps" in the variation. Thus the rate of water influx into the reservoir, as expressed by Eq. 7, can be rewritten as the series expansion

$$\frac{dZ}{d\theta} = \frac{2\pi(144)K\sigma H}{5.62\mu}\sum_{\gamma=1}^{n}(P_{\gamma-1} - P_\gamma)G'\left(\frac{\alpha^2(\theta - \theta_{\gamma-1})}{R^2}\right)$$

Further, if the time of duration for each plateau is reduced to an infinitesimal, there will be an infinite number of "steps," and this expansion approaches as a limit the integral

$$\frac{dZ}{d\theta} = -\frac{2\pi(144)K\sigma H}{5.62\mu} \int_0^\theta \frac{dP}{d\theta'} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' \quad [9]$$

to which the negative sign is prefixed to correct for the order of occurrence of $(P_{\gamma-1} - P_\gamma)$ with time. Likewise the cumulative water influx is expressed as

$$Z = -\frac{2\pi(144)K\sigma H R^2}{5.62\mu\alpha^2} \int_0^\theta \frac{dP}{d\theta'} G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' \quad [10]$$

Therefore Eqs. 9 and 10 are applicable for any pressure variation in the reservoir, by the substitution for $dP/d\theta'$ in the integrands, the actual slopes of the reservoir pressure-time relationship for the field.

It is possible to express these equations as explicit functions of reservoir pressures, instead of pressure slopes, by the expediency of integrating by parts. However, before these integrations can be dealt with, it is necessary to discuss the divergence of $G'(\alpha^2(\theta-\theta')/R^2)$ in the neighborhood of $\alpha^2(\theta-\theta')/R^2 = 0$, in order to satisfy the convergence of the integrals expressed by Eqs. 9 and 10.

Thus for extremely small time arguments, $\alpha^2(\theta-\theta')/R^2$, the problem is comparable to the case in which the time is finite but the radius of the reservoir is extremely large. Under these conditions, then, the influx of fluid into the reservoir approximates a solution to an infinite solid bounded by a plane, and the analysis is essentially that of linear flow. For the linear flow problem, the corresponding values for the functions are

$$G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) = 1/\sqrt{\pi\alpha^2(\theta-\theta')/R^2}$$

and

$$G\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) = \frac{2}{\pi}\sqrt{\pi\alpha^2(\theta-\theta')/R^2}$$

with $\alpha^2(\theta-\theta')/R^2 \leq 0.001$.

Therefore in Eq. 9, if the slope of $dP/d\theta'$ is taken equal to the final slope of the pressure-time curve and the slope is considered as constant from θ_1 to θ where $\theta - \theta_1 \leq 0.001R^2/\alpha^2$,

$$\begin{aligned}\frac{dZ}{d\theta} &= -\frac{2\pi(144)K\sigma H}{5.62\mu}\left[\int_0^{\theta_1} \frac{dP}{d\theta'} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' + \frac{dP}{d\theta}\int_{\theta_1}^{\theta} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta'\right] \\ &= -\frac{2\pi(144)K\sigma H}{5.62\mu}\left[\int_0^{\theta_1} \frac{dP}{d\theta'} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' + 2\frac{dP}{d\theta} R\sqrt{\frac{(\theta-\theta_1)}{\pi\alpha^2}}\right] \quad [11]\end{aligned}$$

which is convergent.

However, an alternative method for expressing Eq. 9 is the following relation,

$$\begin{aligned}\frac{dZ}{d\theta} &= \frac{2\pi(144)K\sigma H}{5.62\mu}\int_0^\theta \frac{d(P_R - P)}{d\theta'} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' \\ &= \frac{2\pi(144)K\sigma H}{5.62\mu}\left[\int_0^{\theta_1} \frac{d(P_R - P)}{d\theta'} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' - \frac{dP}{d\theta}\int_{\theta_1}^{\theta} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta'\right]\end{aligned}$$

which can be deduced from Eq. 7. Thus

$$\begin{aligned}\frac{dZ}{d\theta} &= \frac{2\pi(144)K\sigma H}{5.62\mu}\left\{\left[(P_R - P)G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right)\right]_0^{\theta'=\theta_1}\right. \\ &\qquad \left. + \frac{\alpha^2}{R^2}\int_0^{\theta_1} (P_R - P)G''\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta' - \frac{dP}{d\theta}\int_{\theta_1}^{\theta} G'\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta'\right\} \\ &= \frac{2\pi(144)K\sigma H}{5.62\mu}\left\{(P_R - P)G'\left(\frac{\alpha^2(\theta-\theta_1)}{R^2}\right) + \frac{\alpha^2}{R^2}\int_0^{\theta_1} (P_R - P)G''\left(\frac{\alpha^2(\theta-\theta')}{R^2}\right) d\theta'\right. \\ &\qquad \left. - 2\frac{dP}{d\theta} R\sqrt{\frac{(\theta-\theta_1)}{\pi\alpha^2}}\right\} \quad [12]\end{aligned}$$

where $(P_R - P) = 0$ for $\theta' = 0$. The relation $G''(\alpha^2(\theta - \theta')/R^2)$ is not available for this paper but if necessary it could be computed from G' by either empirical or analytical methods. However, Eq. 11 is explicit in itself for most purposes.

The integration by parts for the cumulative water influx, Eq. 10, is expressed as follows:

$$Z = -\frac{2\pi(144)K\sigma HR^2}{5.62\mu\alpha^2}\left\{\left[PG\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right)\right]_0^{\theta'=\theta} + \frac{\alpha^2}{R^2}\int_0^\theta PG'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right)d\theta'\right\}$$
$$= \frac{2\pi(144)K\sigma HR^2}{5.62\mu\alpha^2}\left\{P_R G\left(\frac{\alpha^2\theta}{R^2}\right) - \frac{\alpha^2}{R^2}\int_0^\theta PG'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right)d\theta'\right\}$$

since $G(\theta) = 0$. However,

$$G\left(\frac{\alpha^2\theta}{R^2}\right) = \frac{\alpha^2}{R^2}\int_0^\theta G'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right)d\theta'$$

and

$$Z = \frac{2\pi(144)K\sigma H}{5.62\mu}\int_0^\theta (P_R - P)G'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right)d\theta'$$

Furthermore, if the final pressure of the pressure-time curve is held constant, say from θ_1 to θ, for $\theta - \theta_1 \leq 0.001R^2/\alpha^2$,

$$Z = \frac{2\pi(144)K\sigma H}{5.62\mu}\left[\int_0^{\theta_1}(P_R - P)G'\left(\frac{\alpha^2(\theta - \theta')}{R^2}\right)d\theta' + 2(P_R - P)R\sqrt{\frac{(\theta - \theta_1)}{\pi\alpha^2}}\right] \quad [13]$$

and this equation expresses reservoir pressure explicitly.

LINEAR FLOW

The linear water drive on a field is represented by the movement of water in a sand formation of uniform cross section, bounded at one end by the field and extending in the other direction for infinite distances. The constant terminal pressure solution for the linear-flow case is given in Carslaw,[7] and it is expressed as

$$P = \frac{2}{\sqrt{\pi}}\int_0^{x/2\sqrt{\alpha^2\theta}} \epsilon^{-\xi^2}\,d\xi \quad [14]$$

for $P = 1$ at any point in the water formation in zero time, with $P = 0$ at $x = 0$, where x is the distance measured from the edge of the field.

As in radial flow, the reservoir pressure change is reproduced by the application of the "step-fashion" pressure variation of Eq. 2. Thus the pressure in the water formation at any distance x in time θ is developed by superimposing the constant terminal pressure solutions for times zero, θ_1, θ_2, etc. (See Eq. 15, below.)

The rate of water influx into the reservoir at $x = 0$ is expressed by Darcy's law

$$\frac{dZ}{d\theta} = \frac{(144)KA}{5.62\mu}\left(\frac{dP}{\partial x}\right)_{x=0} \quad [16]$$

where A, in sq. ft., is the cross-sectional area exposed to water drive. Thus the differentiation of Eq. 14 with respect to x for the limit $x \to 0$, gives

$$\left(\frac{\partial P}{\partial x}\right)_{x=0} = \frac{1}{\sqrt{\pi\alpha^2\theta}} \quad [17]$$

for the over-all pressure drop of unity.

$$P(x, \theta) = \frac{2}{\sqrt{\pi}}\left[(P_R - P_1)\int_0^{x/2\sqrt{\alpha^2\theta}} \epsilon^{-\xi^2}\,d\xi + (P_1 - P_2)\int_0^{x/2\sqrt{\alpha^2(\theta-\theta_1)}} \epsilon^{-\xi^2}\,d\xi\right.$$
$$\left. + (P_2 - P_3)\int_0^{x/2\sqrt{\alpha^2(\theta-\theta_2)}} \epsilon^{-\xi^2}\,d\xi + \cdots + (P_{n-1} - P_n)\int_0^{x/\sqrt{\alpha^2(\theta-\theta_{n-1})}} \epsilon^{-\xi^2}\,d\xi\right] \quad [15]$$

Therefore, by Eqs. 15 and 17, the rate of water influx is expressed as

$$\frac{dZ}{d\theta} = \frac{144KA}{5.62\mu\sqrt{\pi\alpha^2}}\left[\frac{(P_R - P_1)}{\sqrt{\theta}} + \frac{(P_1 - P_2)}{\sqrt{(\theta - \theta_1)}} + \frac{(P_2 - P_3)}{\sqrt{(\theta - \theta_2)}} + \cdots + \frac{(P_{n-1} - P_n)}{\sqrt{(\theta - \theta_{n-1})}}\right] \qquad [18]$$

and the cumulative water influx by the relation

$$Z = \frac{144KA}{5.62\mu\sqrt{\pi\alpha^2}}\left[(P_R - P_1)\int_0^\theta \frac{d\theta}{\sqrt{\theta}} + (P_1 - P_2)\int_{\theta_1}^\theta \frac{d\theta}{\sqrt{(\theta - \theta_1)}} + (P_2 - P_3)\int_{\theta_2}^\theta \frac{d\theta}{\sqrt{(\theta - \theta_2)}} + \cdots + (P_{n-1} - P_n)\int_{\theta_{n-1}}^\theta \frac{d\theta}{\sqrt{(\theta - \theta_{n-1})}}\right]$$

$$= \frac{2(144)KA}{5.62\mu\sqrt{\pi\alpha^2}}\left[(P_R - P_1)\sqrt{\theta} + (P_1 - P_2)\sqrt{(\theta - \theta_1)} + (P_2 - P_3)\sqrt{(\theta - \theta_2)} + \cdots + (P_{n-1} - P_n)\sqrt{(\theta - \theta_{n-1})}\right] \qquad [19]$$

If the pressure plateaus are assumed to occur in infinitesimal steps, Eqs. 18 and 19 approach the limits

$$\frac{dZ}{d\theta} = -\frac{144KA}{5.62\mu\sqrt{\pi\alpha^2}}\int_0^\theta \frac{dP}{d\theta'}\frac{d\theta'}{\sqrt{(\theta - \theta')}} \qquad [20]$$

and

$$Z = -\frac{(2)(144)KA}{5.62\mu\sqrt{\pi\alpha^2}}\int_0^\theta \frac{dP}{d\theta'}\sqrt{(\theta - \theta')}\,d\theta' \qquad [21]$$

Therefore, by the integration by parts,

$$\frac{dZ}{d\theta} = \frac{144KA}{5.62\mu\sqrt{\pi\alpha^2}}\left[\frac{(P_R - P)}{\sqrt{(\theta - \theta_1)}} + \frac{1}{2}\int_0^{\theta_1}\frac{(P_R - P)}{(\theta - \theta')^{3/2}}\,d\theta' - 2\frac{dP}{d\theta}\sqrt{(\theta - \theta_1)}\right] \qquad [22]$$

where $dP/d\theta$ is assumed constant for $\theta_1 \leq \theta' \leq \theta$ with $(\theta - \theta_1)$ small. Further,

$$Z = \frac{144KA}{5.62\mu\sqrt{\pi\alpha^2}}\left[\int_0^{\theta_1}\frac{(P_R - P)\,d\theta'}{(\theta - \theta')^{3/2}} + 2(P_R - P)\sqrt{(\theta - \theta_1)}\right] \qquad [23]$$

for the final pressure P constant in the same interval.

SPHERICAL FLOW

It is possible that the water drive is from a formation of infinite extent, concentric with an oil field, and subtended by a spherical angle at the center of the field. An examination of the literature, however, has failed to reveal the constant terminal pressure solution for this case, therefore this analysis will be developed in detail.

The comparable form to Eq. 1 in spherical flow is the relation

$$\frac{\partial^2(\Phi r)}{\partial r^2}\alpha^2 = \frac{\partial(\Phi r)}{\partial\theta}$$

which is similar to the linear-flow equation, and the solution is expressed by

$$\Phi r = \frac{1}{2\sqrt{\pi\alpha^2\theta}}\int_{-\infty}^{+\infty} f(r')\epsilon^{-\frac{(r - r')^2}{4\alpha^2\theta}}\,dr'$$

where $f(r') = f(r)$, the value of Φr in zero time at any point r.

Further, if the limits are taken that $\Phi = 1$ at zero time for $r > R$, the radius of the oil field, and $\Phi = 0$ at $r = R$, the $f(r)$ value in the equation is expressed by

$$\Phi r = f(r) = r; \qquad r > R$$

and

$$\Phi r = f(r) = r - 2R; \qquad r < R$$

Thus it is observed that for $r < R$ the $f(r)$ function is so chosen as to give the odd function of $f(r)$, or the negative image of this function. Therefore

$$\Phi r = \frac{1}{2\sqrt{\pi\alpha^2\theta}}\left[\int_R^\infty r'\epsilon^{-\frac{(r - r')^2}{4\alpha^2\theta}}\,dr' + \int_{-\infty}^R (r' - 2R)\epsilon^{-\frac{(r - r')^2}{4\alpha^2\theta}}\,dr'\right]$$

or the form

$$\Phi r = \frac{1}{2\sqrt{\pi\alpha^2\theta}}\left[\int_R^\infty \xi\left(\epsilon^{-\frac{(r-\xi)^2}{4\alpha^2\theta}} - \epsilon^{-\frac{(r+\xi-2R)^2}{4\alpha^2\theta}}\right)d\xi\right] \quad [24]$$

The rate of water influx into the oil reservoir is expressed by the equation

$$\frac{dZ}{d\theta} = \frac{4\pi(144)K\sigma R^2}{5.62\mu}\left(\frac{\partial\Phi}{\partial r}\right)_{r=R} \quad [25]$$

where the spherical surface is equal to $4\pi R^2$ and σ is the fraction of the surface exposed to water drive. Therefore the differentiation of Eq. 24 gives the relation

$$\left(\frac{\partial(\Phi r)}{\partial r}\right)_{r=R} = R\left(\frac{\partial\Phi}{\partial r}\right)_{r=R} = \frac{1}{2\sqrt{\pi}(\alpha^2\theta)^{3/2}} \int_R^\infty \xi(\xi - R)\epsilon^{-\frac{(\xi-R)^2}{4\alpha^2\theta}}\,d\xi$$

since $\Phi = 0$ at $r = R$.
Thus by integrating

$$\left(\frac{\partial\Phi}{\partial r}\right)_{r=R} = \frac{1}{R}\left(\frac{1}{\sqrt{\pi\alpha^2\theta/R^2}} + 1\right) \quad [26]$$

Finally, employing the "step-fashion" variation of Eq. 2, we obtain Eq. 27,

$$\frac{dZ}{d\theta} = \frac{4\pi(144)K\sigma R}{5.62\mu}\left[(P_R - P_1)\left(\frac{1}{\sqrt{\pi\alpha^2\theta/R^2}} + 1\right) + (P_1 - P_2)\left(\frac{1}{\sqrt{\pi\alpha^2(\theta - \theta_1)/R^2}} + 1\right) + \cdots + (P_{n-1} - P_n)\left(\frac{1}{\sqrt{\pi\alpha^2(\theta - \theta_{n-1})/R^2}} + 1\right)\right] \quad [27]$$

where Φ is referred to a given datum plane and therefore can be expressed as reservoir pressure. The limit, however, for Eq. 27, taking infinitesimal steps, is the equation

$$\frac{dZ}{d\theta} = -\frac{4\pi(144)K\sigma R}{5.62\mu}\int_0^\theta \frac{dP}{d\theta'}\left(\frac{1}{\sqrt{\pi\alpha^2(\theta - \theta')/R^2}} + 1\right)d\theta' \quad [28]$$

and the cumulative water influx is the expression

$$Z = -\frac{4\pi(144)K\sigma R^3}{5.62\mu\alpha^2}\int_0^\theta \frac{dP}{d\theta'}\left(2\sqrt{\frac{\alpha^2(\theta - \theta')}{\pi R^2}} + \frac{\alpha^2(\theta - \theta')}{R^2}\right)d\theta' \quad [29]$$

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Pressure Prediction for Oil Reservoirs

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(New York Meeting, February 1942)

Abstract

This paper presents the essentials of a mathematical method of studying the pressure behavior of an oil reservoir as the fluids are withdrawn. Methods are shown whereby the behavior of a reservoir can be used to predict the future relationship between withdrawals and pressure. The oil reservoir is considered as a small part of a large porous continuum, which contains for the most part water. The expansion of this water resulting from a decrease of pressure in the oil zone causes a movement of water that is an important factor in the relationship between fluid withdrawals and reservoir pressure. Examples are given to illustrate the methods of pressure prediction for a circular reservoir containing undersaturated crude, the pressure distribution over a field that has a uniform production rate, the effect of a fault line near a field, the mutual interference of near-by fields, and the perturbing influence of a gas cap. Applications of the analysis to well-spacing problems are shown.

Introduction

The pressure-prediction methods to be described here are based upon the conception of an oil pool as a small part of a large porous continuum, containing for the most part water. The formation containing this water may be thought of as extending over an area of many square miles and having one or more small bodies of oil or gas trapped in high spots or reservoirs. It will be treated as having the general aspect of a thin, flat sheet with an over-all tilt to the horizontal and with numerous small high spots, tight zones, and irregularities. This porous continuum will be treated as being much more extensive than the oil or gas zones, but will be recognized as terminating at such large boundaries as a general fault, outcrop, unconformity, or pinch-out.

Throughout the greater part of this limited porous continuum it is likely that there is a hydraulic connection. If this is true, the removal of fluid in one place will cause a disturbance that eventually will travel to all parts of the continuum.

This picture has led to the recognition of water as the major fluid in the porous continuum and in many cases the expansive nature of this water as the main driving force producing the oil. The next step is the solution of the general problem of compressible liquid behavior in porous media.

The works of Hurst[1] and Muskat[2] introduced the idea of using heat-flow mathematics to consider the problem of compressible liquid flow in a porous medium. Before their reports, it had been thought sufficient to use the incompressible fluid-flow work of Slichter.[3]

Later Muskat[4] pointed out in detail how far the incompressible-fluid assumption deviated from fact even for water, of which the compressibility is about 3×10^{-6} volumes per unit volume per pound per square inch. He showed that this deviation increased with increases of distance. For example, the incompressible-fluid formula might show good agreement with the

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* The Carter Oil Co., Tulsa, Oklahoma.

[1] References are at the end of the paper.

compressible in the case of pressure distribution near a well, but would show considerable deviation in the problem of an entire oil field more than a mile long.

By consideration of the expansive forces of water on an oil reservoir, Schilthuis and Hurst[5] and Muskat[4] studied the problem of production vs. pressure at East Texas. Muskat assumed production into a part circle and the others assumed that the production was along a thin line. In both cases there was fairly good agreement with the observed behavior of the field. It was pointed out by Muskat, however, that in order to get good agreement, it was necessary to assume a compressibility for water 12 times that measured in the laboratory.

The work published on this subject indicates that the concept of a reservoir of expansible water is a good one, but that the source and magnitude of expansive forces and exact nature of resistance to reservoir fluid flow is open to further investigation. It has been suggested that the effect of the natural expansion of water may be increased by expansion of reservoir rock or by expansion of free gas or release of dissolved gas. Whatever the nature of these effects that appear as constants in the solution of the differential equation expressing the fluid behavior, their effective values can be determined by an inverse solution of the problem in which the actual behavior of the reservoir can be used to evaluate constants in an equation that will predict future behavior. At present a relatively brief part of the history can be used to extend the prediction into the future and to permit the evaluation of possible effects due to changes in production rate or method.

The question might be raised that if constants must be determined from field behavior, why not use an entirely empirical equation in which enough constants are placed to account for any behavior? The answer is that, by use of the analysis, the factors of geometry and conservation of mass are so combined that the adjustable constants can be reduced to two (permeability and compressibility) and these are held to relatively small variations.

From this point of view, it is evident that everything possible should be done to take proper account of the geometrical factors, such as producing zones of irregular shapes, the proximity of a fault or unconformity, the interference of near-by pools, and the size of the porous continuum.

It is feasible to account for most geometrical factors, and, accordingly, an analytical method was devised to do this.

ANALYTICAL DEVELOPMENT

For the present analytical development the following assumptions are made: A homogeneous compressible liquid is contained in an infinite, horizontal, uniformly thick and homogeneous porous medium. Methods for deviating from these assumptions will be indicated in the solution of practical problems.

At any time t_1 the distribution of density,* γ_1, throughout the continuum will be given by some function $F_1(x, y, t_1)$. This function necessarily will satisfy the following differential equation:[1,2]

$$K\left(\frac{\partial^2\gamma}{\partial x^2} + \frac{\partial^2\gamma}{\partial y^2}\right) = \frac{\partial\gamma}{\partial t} \qquad [1]$$

It will also have to agree with the boundary conditions and the density throughout the system at the time t_1. If some new disturbance is contemplated at x_1, y_1, and at the instant t_1, it may be entirely accounted for by subtracting a term $F_2(x, y, t_1)$ from the solution $F_1(x, y, t_1)$ such that the density γ is now

$$\gamma = F_1(x, y, t_1) - F_2(x, y, t_1) \qquad [2]$$

(The essentials of this development were indicated by Kelvin[6] in 1842 in connection with problems of heat flow and diffusion.) Eq. 2 now accounts for the change in density caused by the disturbance F_2, and in addition F_2 can be constructed so that it does not alter the boundary conditions. In the problem here $F_1(x, y, t)$ is a constant at the boundary infinity, or if finite boundaries exist across which no fluid flows, they are accounted for by images that in turn have terms that become constant as x and y become infinite.

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* Nomenclature is on page 84.

It can be shown[6,7] that the following equation:

$$\gamma = F_1(x, y, t) - \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F_2(x', y', t_1) \frac{e^{-\frac{(x-x')^2+(y-y')^2}{4K(t-t_1)}}}{4\pi K(t-t_1)}\, dx'dy' \qquad [3]$$

is an expression that satisfies the differential equation, equals F_1 at the boundaries and becomes $F_1(x, y, t_1) - F_2(x, y, t_1)$ at $t = t_1$. Hence, it is a unique solution and the change in density $\Delta\gamma$, as a result of the effect of $F_2(x, y, t_1)$, is given by:

$$\Delta\gamma = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} F_2(x', y', t_1) \frac{e^{-\frac{(x-x')^2+(y-y')^2}{4K(t-t_1)}}}{4\pi K(t-t_1)}\, dx'dy' \qquad [4]$$

If $F_1(x, y, t)$ is a constant, γ_0, no other variation need be considered, but if F_1, the original density distribution, has space variations due to previous production, or to production in some other place, it must be continued in accordance with its original development in time and space just as though the disturbance F_2 had never been. An infinite number of disturbances such as F_2 can be included, and each can have different space and time conditions. At t_1, F_2 corresponds to the decrease in density caused by removal of $Q(x', y', t_1)dx'dy'$ mass units of fluid from the reservoir at the point x', y' at the instant t_1. The density decrease at the block $dx'dy'$ square and b thick will be $Q(x', y', t_1)/fb$, f indicating porosity. Hence the decrease at any point x, y and any time t_2 will be:

$$\Delta\gamma = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \frac{Q(x', y', t_1)}{4\pi Kfb}\, e^{-\frac{(x-x')^2+(y-y')^2}{4K(t_2-t_1)}} \frac{dx'dy'}{t_2 - t_1} \qquad [5]$$

If, instead of Q mass units per unit area at t_1, $\gamma q(t')dt'$ units are removed in the interval dt' in which $q(t')$ is the per unit area per unit volume production rate and γ is the density of the flowing fluid, the decrease in density due to flow from t_1 until t_2, is:

$$\Delta\gamma = \int_{t_1}^{t_2}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \frac{\gamma q(x', y', t')}{4\pi Kfb}\, e^{-\frac{(x-x')^2+(y-y')^2}{4K(t_2-t')}} \frac{dx'dy'dt'}{(t_2 - t')} \qquad [6]$$

In the special case of a "ring" of production (see the inner ring, Fig. 1) the integral becomes:

$$\Delta\gamma = \frac{r\Delta r}{4\pi Kfb}\int^{t_2}\int_0^{2\pi} \gamma q(t') e^{-\frac{a^2+r^2-2ar\cos\theta}{4K(t_2-t')}} \frac{d\theta dt'}{t_2 - t'} \qquad (7)$$

and this becomes as shown by Carslaw[7]

$$\Delta\gamma = \frac{r\Delta r}{2Kfb}\int_{t_1}^{t_2} \frac{\gamma q(t') e^{-\frac{a^2+r^2}{4K(t_2-t')}}}{t_2 - t'}\, I_0\left(\frac{ar}{2K(t_2 - t')}\right) dt' \qquad [8]$$

(This is the same solution obtained by Muskat[4] for a similar problem. He used the approach of the point sink and considered the total production coming from an infinitesimally thin circular line. Here the production is assumed to come from an area, $2\pi r\Delta r$, in which Δr may be as wide as is practical from the point of view of numerical accuracy.)

The most important use of this will be the special case in which $a = 0$. Then

$$\Delta\gamma = \frac{r\Delta r}{2Kfb}\int_{t_1}^{t_2} \gamma q(t') e^{-\frac{r^2}{4K(t_2-t')}} \frac{dt'}{(t_2 - t')} \qquad [9]$$

Eq. 6 is the general equation. However, for practical calculations Eq. 9 can be put into a most advantageous form as follows: Consider an area (Fig. 1) in which it is desired to calculate the change in density at a point P. (P is now associated with $a = 0$.) Each ring or portion of a ring (see outer ring, Fig. 1) will contribute to the density reduction at P in accordance with r and the arc length of the broken ring. The ring length is stated in the form of an angle, or the fraction of 360° which it subtends. Hence, if the fraction is $h(r)$ and $q(t')$ is uniform over the producing area, the total

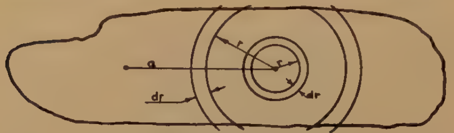


FIG. 1.—OUTLINE OF OIL ZONE SHOWING RINGS OF PRODUCTION.

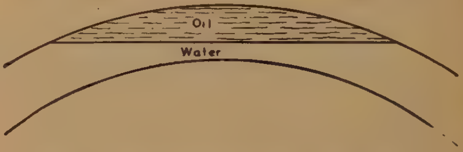


FIG. 2.—IDEALIZED PROFILE OF A POOL.

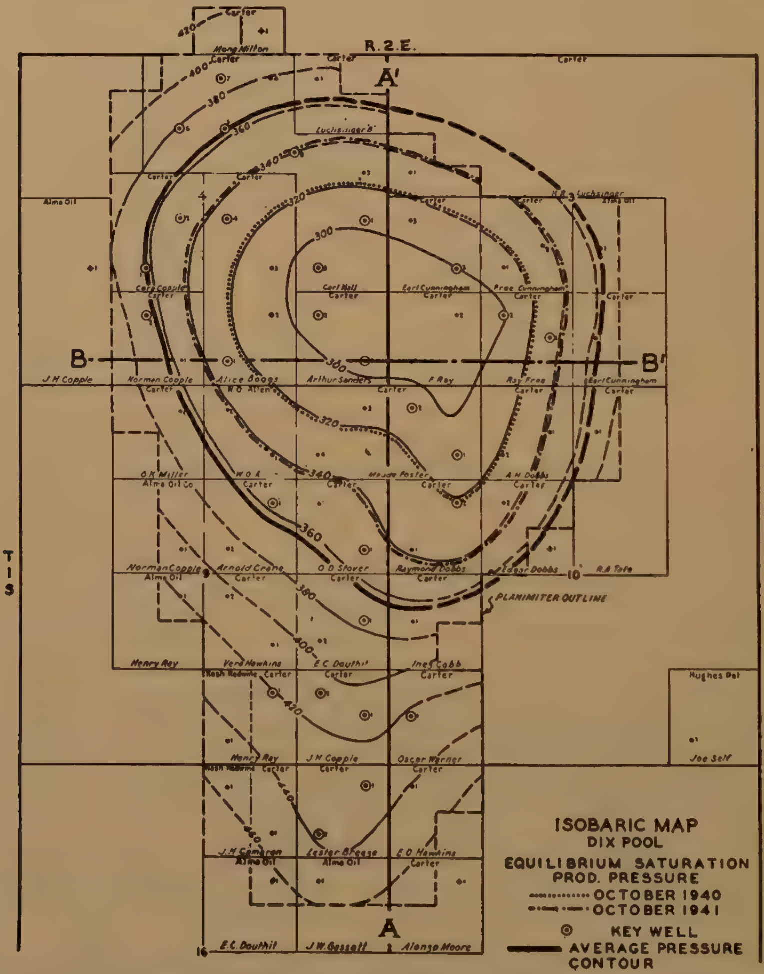


FIG. 3.—MAP OF DIX POOL; ALSO "BUBBLE-POINT" ISOBAR OCTOBER 1940 AND CALCULATED FOR 1941.

effect may be written

$$\Delta\gamma = \frac{1}{2Kbf}\int_0^R \int_{t_1}^{t_2} \gamma q(t') e^{-\frac{r^2}{4K(t_2-t')}} \frac{dt'}{(t_2-t')} rh(r)dr \qquad [10]$$

This entails the plotting of $h(r)$ if the production is uniform. If it is not uniform, Eq. 6 can be used.

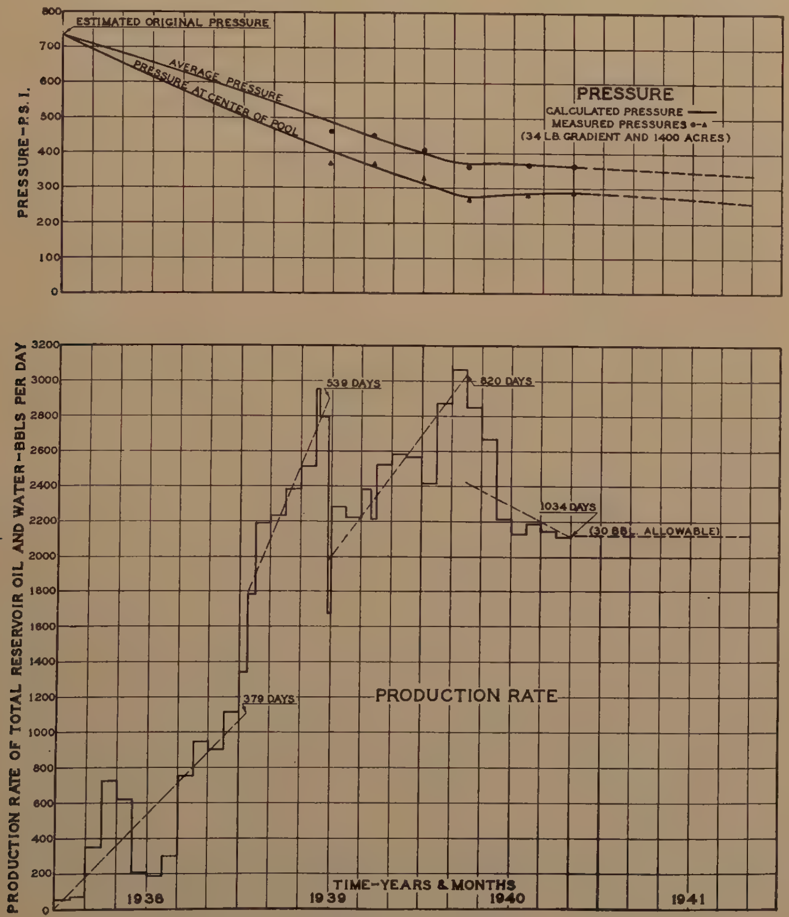


FIG. 4.—CALCULATED AND OBSERVED PRESSURES AT DIX, ILLINOIS.

In reservoir problems it is usual to deal with pressure changes rather than changes in density. Eq. 10 may be readily converted to this form by assuming[1,2] that the compressibility is small and that suitable corrections are made to convert from stock tank barrels measured to subsurface barrels flowing. The pressure drop Δp caused by production rate of $q(t')$ per unit area per day is given by:

$$\Delta p = \frac{\mu}{2kb}\int_0^R \int_{t_1}^{t_2} q(t') e^{-\frac{r^2}{4K(t_2-t')}} \frac{dt'}{(t_2-t')} rh(r)dr \qquad [11]$$

Calculations with this formula can be simplified by use of *Ei*-functions. The Bureau of Standards has recently issued a table of *Ei*-functions in connection with its W. P. A. mathematical tables project.

EXAMPLES OF PRESSURE PREDICTION

From the method standpoint, the illustrations of possible methods for predicting pressures in and near oil reservoirs are divided as follows:

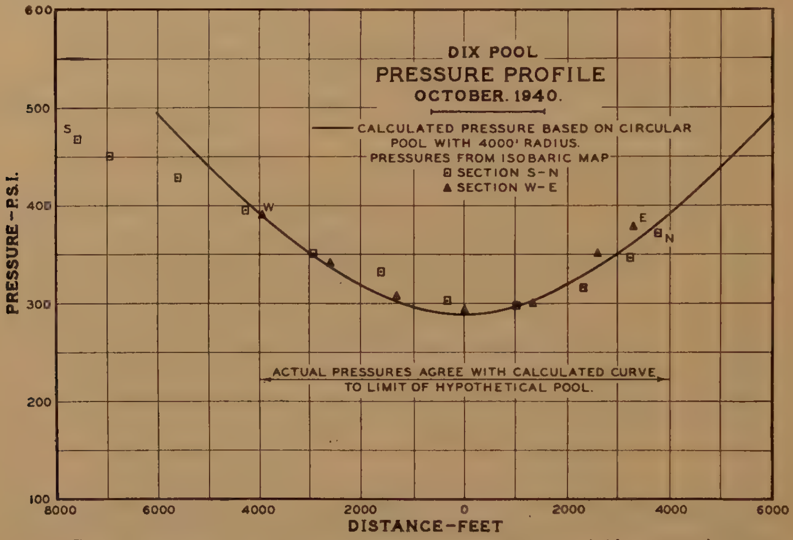


FIG. 5.—CALCULATED AND OBSERVED PRESSURES ALONG LINES AA' AND BB' OF FIG. 3.

1. *Pools of Undersaturated Crude not Affected by Near-by Pools and Remote from Large Impermeable Barriers.*—In this type it will be assumed that the expansion of the oil and water is the driving force. The higher compressibility of the oil, complicated relative permeability effects in the oil-water interface zone, and local change in sands or fluids are assumed to be averaged out, or accounted for, by the two adjustable constants. If these assumptions are unjustifiable, a discrepancy will develop between the observed pressures and the calculated pressure distribution across the field in a comparison such as is shown in Fig. 5.

2. *Pools Near Enough to Each Other or Near Enough to Faults or Impermeable Barriers to Cause Measurable Interference Effects.*—These effects are taken care of by extra terms in the analytical expressions.

3. *A Pool or Pools Having a Gas Cap and Saturated Crude.*—The conditions described in paragraph 1 will apply to the oil zone and, in addition, special account will have to be taken of the gas zone and gas coming out of solution.

4. *The Problem of Irregular Production (Nonuniform Well Distribution or Well Production).*

An Undersaturated Fluid Reservoir

The problem to which this work is most easily applicable is one in which the oil part of the porous layer is undersaturated. Such a case was found at Dix, Ill. The field is a small anticlinal structure of about 30 ft. productive closure. It is in a fairly uniform part of the Bethel sand, with known boundaries at least 40 miles from Dix. An idealized profile of the pool is shown in Fig. 2.

The production has been on an almost uniform per acre rate and Eq. 11 is the one to use. At the time the calculations were made 2½ years of production and pressure history were available from which to fix the constants K and μ/kb.

In the use of Eq. 11, it is assumed that the fluid is withdrawn from the reservoir in proportion to the area without any consideration of the mechanism of withdrawal.

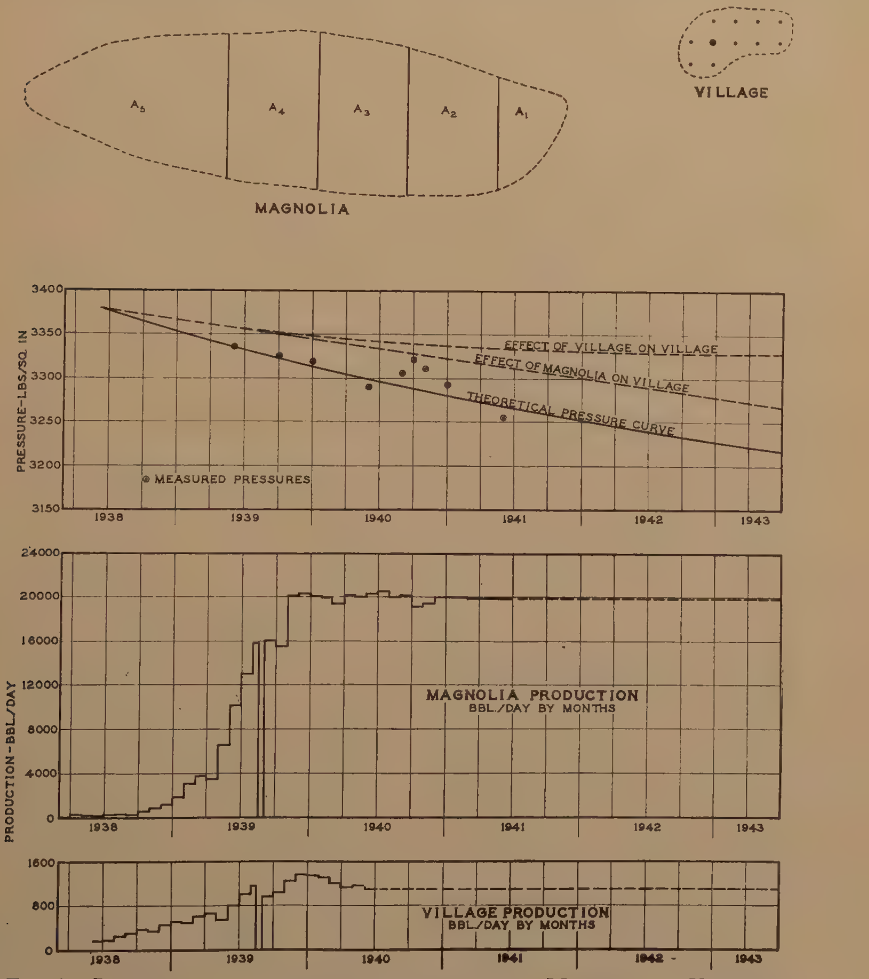
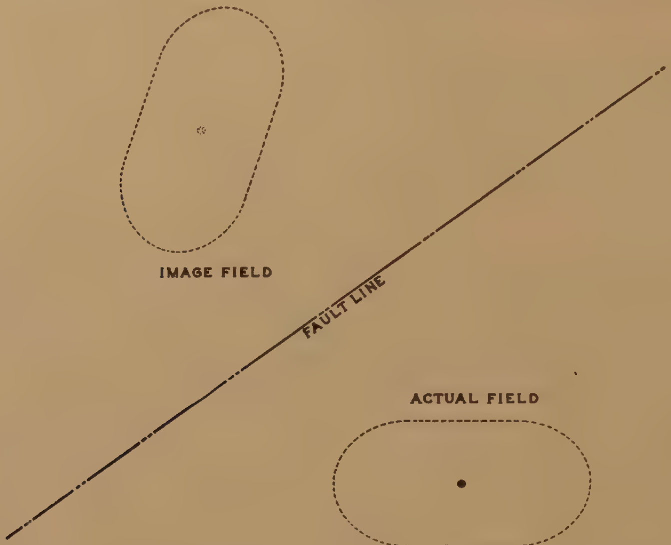


FIG. 6.—ILLUSTRATION OF PRESSURE INTERFERENCE OF MAGNOLIA ON VILLAGE.

Actually, the fluid is withdrawn by wells on 20-acre spacing. During flow each well will produce a drop in pressure, which is very sharp near the well. These local low-pressure areas near the well are smoothed out when the well is shut in. Pressure studies on shut-in wells where shut-in time is sufficient to account for the local effect would not be dependent upon the number of wells, method of completion, or mechanical equipment provided the same uniform per acre rate were maintained.

The boundary condition in this problem is assumed to be that of constant pressure at infinite distance from the pool. In this case the assumption is logical because no extensive impermeable barriers are known to be near the pool. The effect of the finite size of the porous continuum will be discussed in connection with a later problem.

A map of the pool is shown in Fig. 3. The production history, pressure history, together with pressures at the center of the pool and the average pressure contour predicted from Eq. 11, are shown in Fig. 4.



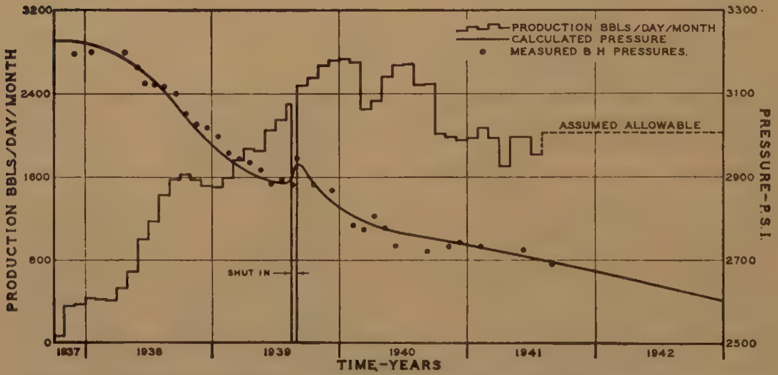


Fig. 7.—Calculated and experimental pressures at Buckner, Arkansas.

The term μ/kb from laboratory work was 0.626; in the equation it was 0.694. The term K from laboratory work was 1.27×10^5; in the equation, 1.11×10^5.

This would indicate that the mechanism as pictured might be close to the actual case.

A cross check to this work was found by calculating, from Eq. 11 with constants determined as described above, the pressure to be expected October 1940 along a line drawn east and west through the center of the field. The calculation (Fig. 5) was then compared with observed pressures along the lines AA' and BB' of Fig. 3. The agreement here is evidence that proper account of the local geometrical factors is taken by the analysis used.

Mutual Interference

The development so far would indicate that two near-by pools could interfere with each other if they have a hydraulic connection. This interference may be expressed as the pressure reduction in one pool resulting from fluid production in an adjacent pool.

An application of these ideas to the pressure behavior in the Magnolia and Village pools (Smackover lime) has been attempted. So far the development of these pools has been too recent for any significant experimental check, but the method used and results obtained will be presented.

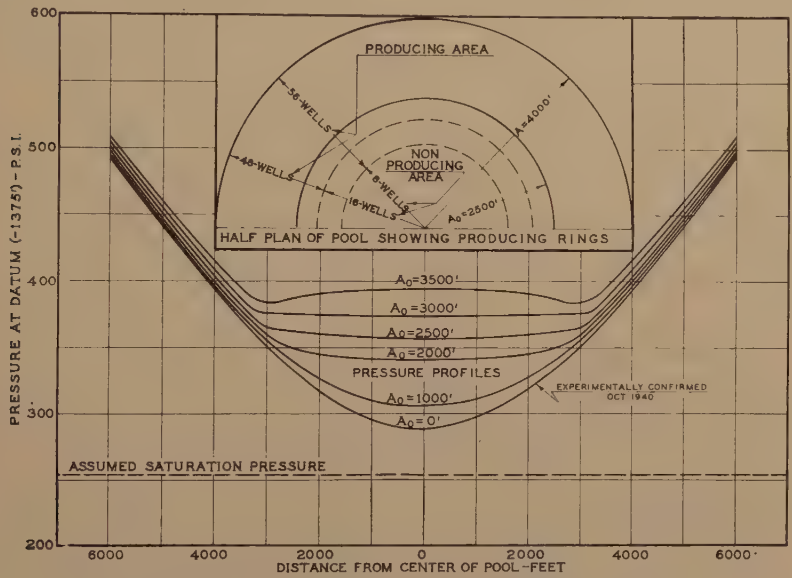


FIG. 8.—THEORETICAL PRESSURE PROFILE RESULTING FROM TRANSFERRING CENTER PRODUCTION TO OUTER WELLS. CONDITIONS TAKEN FROM DIX POOL.

Fig. 6 shows an outline of Magnolia producing area and a plot of the wells at Village. The pools are 1½ miles apart. Individual well production was used and summed at Village because so few wells were in the pool that it was simpler to sum the effects of the wells than to integrate, and, in addition, slightly more accurate. A reduced form of Eq. 11 was used for each well, in which R was the radius of the well, and for all times at which t_2 did not approach too close to t' the equation becomes:

$$\Delta p = \frac{\mu}{4\pi kb}\int_{t_1}^{t_2} q(t')e^{-\frac{r^2}{4K(t_2-t')}}\frac{dt'}{(t_2-t')} \qquad [12]$$

To further simplify the problem, the Magnolia pool was divided into five areas, each of which was assumed to be a unit.

The three pressure curves shown in Fig. 6 are: (1) the pressure effect at Village of the production in the Village wells on the basis of the assumption that there was no Magnolia production, (2) the effect of the Magnolia production on the center well in Village on the basis of the assumption that there was no production at Village, (3) the sum of these two effects. Experimental pressures are shown as points. Fig. 6 shows that the Magnolia production has considerable importance in the pressure behavior at Village. Eq. 11 indicates that it will have increasing importance as time goes on.

Effect of a Gas Cap

A study of these two fields introduces a new variable into the picture. Both have free gas presumably in equilibrium with the oil. Thus, any decrease in pressure causes the evolution of more free gas and the expansion of the gas that is already free.

Actually, in this particular case, the high pressures make this effect less noticeable than is usual in low-pressure pools. It is, however, a problem that must be recognized and properly handled.

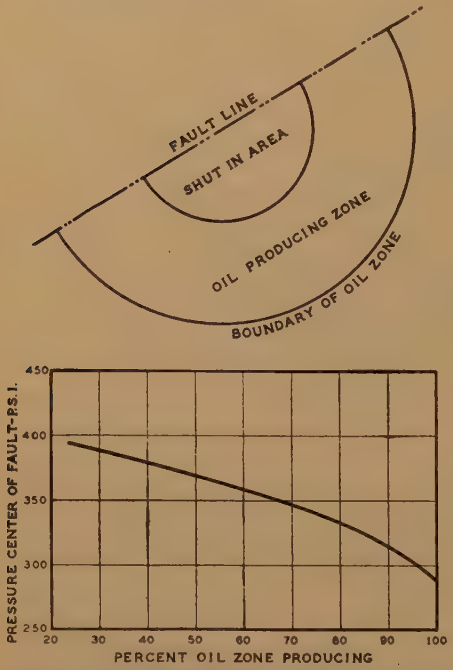


FIG. 9.—ILLUSTRATION OF RELATIVE PRESSURES RESULTING FROM TRANSFERRING PRODUCTION AWAY FROM FAULT LINE.

One method would be to imagine that the gas-oil interface is a large piston face and that this piston would move back or forth to account for physical changes in the fluid in excess of those already accounted for by the liquid-compressibility effect contained in the analysis. This corresponds to the material balance method.[8,9]

Another method would be to imagine an amount of fluid returned to the formation equal to the expansion of the gas plus gas out of solution. This would involve a rather complicated equation for direct solution, but by a stepwise method it is simple. First, the pressure is determined on the basis of no gas out of solution. This pressure curve, together with reservoir fluid pressure-volume data, will give the increase in reservoir fluid volume. The voids filled with free gas are then subtracted from withdrawals, which in turn yield a new pressure curve. With luck this process need be followed only once. Certainly three trials will be sufficient to bracket the experimentally observed pressure behavior. Of these methods the latter is favored at present.

The increased complexity of the problem by introduction of the gas phase will probably be accompanied by a decrease in accuracy of prediction. First, the higher compressibility and fluidity in the gas zone will tend to flatten out pressure gradients across the field. Second, if free gas is dispersed throughout the oil it will cause a greater divergence between the behavior of the oil and water zones. Opposed to these objections, it is observed that the gas cap usually will not extend its perturbing force over all of the pool. As to the free gas dispersed throughout the oil, this may not be in large quantities except near the well bore of a flowing well. This has been mentioned previously as a local anomaly.

Production Near a Fault

In the two problems shown it has been assumed that the external boundary was so remote that it was necessary only to assume that at infinity there would be no flow. This is a natural inclusion in Eq. 11, hence no special treatment was necessary.

The pools, Magnolia and Village, are in the central part of the Smackover Lime, an oölitic lime formation of more than 3000 sq. miles extent. No fluid flow will take place perpendicular to any boundary of this porous continuum and this fact can be taken care of analytically by images placed in offset positions. The test of the need of these images is the numerical magnitude of their effect relative to measurable pressures. At the present time the numerical value of the image effects for either of the problems just illustrated is negligible.

One other problem encountered in the Smackover does require an image—the pressure prediction at Buckner, Ark. The producing field and its relation to the fault line* are depicted in Fig. 7.

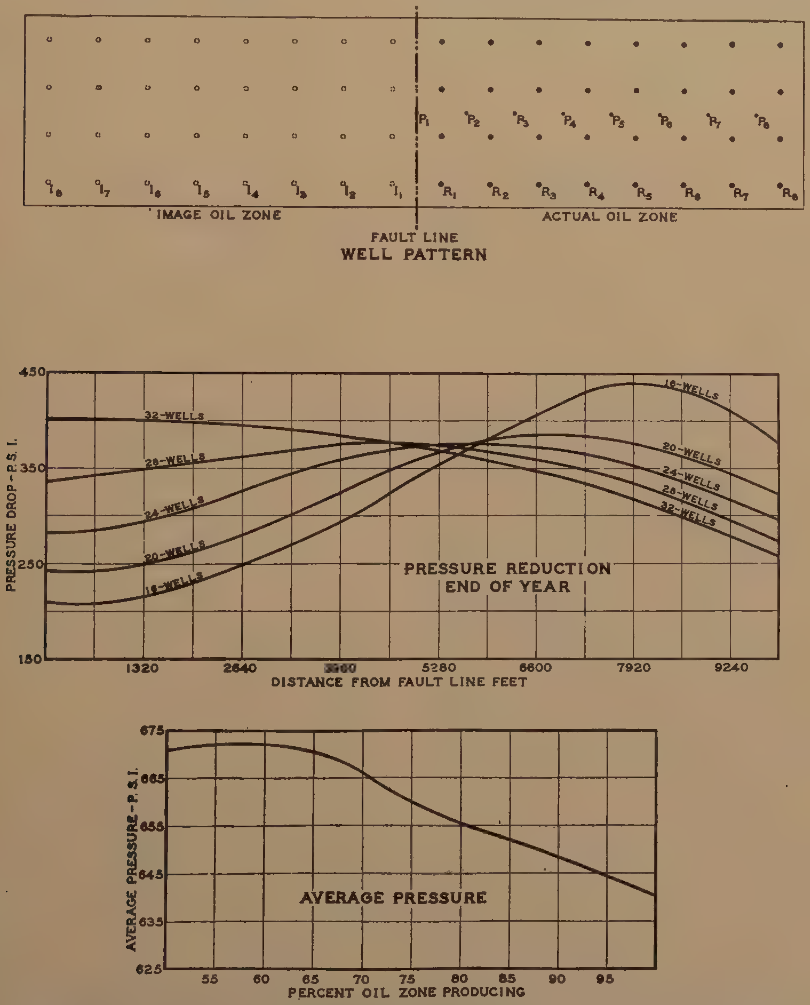


FIG. 10.—PRESSURE CHANGES DUE TO TRANSFER OF PRODUCTION FROM WELLS NEAR FAULT TO WELLS AWAY FROM FAULT.

The presence of the barrier to flow shown can be completely accounted for in the analysis by placing an image "offset" to the pool across the barrier (Fig. 7). The pressure drop observed at the pool as a result of production will then be the sum of the effects of the pool and its image. Evidently, the effect of the image will be very small in the early life of the pool and will grow larger as time goes on. Two terms, each composed of equations like Eq. 11, are needed. Both the pool and the image must be represented by a term.

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* Actually the barrier to fluid flow is inside the fault line and at the present time it is a little uncertain as to where the line should be drawn.

Well Distribution

The foregoing equations and the methods described are in suitable form to analyze a problem of the pressure effects resulting from variations in withdrawal rate in various parts of the oil zone. A practical use of this may be the consideration of relative pressure effects resulting from different well distributions.

A simple illustration of this was worked out for the Dix pool, assuming that it was circular (Fig. 8). It was assumed that the number of wells needed to get the daily allowable of oil would be drilled. From Fig. 8 it is found that shutting in production at the center wells will obtain higher pressures in the oil zone.

This suggested well distribution was particularly interesting at Dix because the wells could get their allowable with a 6-hr. pumping cycle. The pressure drawdown in this time is about 80 lb. per sq. in. By pumping 88 per cent of the wells 7 hr. the same total rate of oil production could be obtained with a drawdown of only 3 lb. per sq. in. more. The reduction of the number of wells by 12 per cent would cause a 10 per cent increase in average pool pressure at the end of the year. It is to be remembered that the equation and constants from which these figures were obtained were the same that gave the agreement shown in Figs. 4 and 5.

Figs. 9 and 10 show the effects of cutting out production in a fault-line pool. Fig. 10 shows that the pressure behavior is improved by cutting out production straight back from the fault line, but not as much as in the cases of annular ring production depicted in Figs. 8 and 9.

Acknowledgment

The author is indebted to Russell Curtis and John Cooke for assistance in organization and calculation of the examples shown and to the management of The Carter Oil Co. for permission to publish this paper.

Nomenclature

a, x, y, r, R, distances, ft.
t, t_1, t_2, t', times, days
γ, density
$q(t)$, rate of flow, bbl. per day per sq. ft. developed area
Q, mass units
K, diffusivity $= k/f\mu c$
k, permeability
f, porosity
μ, viscosity
c, compressibility

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DISCUSSION

(*Eugene A. Stephenson presiding*)

W. Hurst,[*] Dallas, Texas.—It is significant to state that the use of the instantaneous point sink as given here, and the application of the diffusivity theory in general, is an extremely useful tool to the petroleum engineer in interpreting fluid flow in oil reservoirs. Dr. Bruce has shown its application to the study of pressure behavior in the Dix, Magnolia, and Village pools, and the results confirm the validity of earlier studies in predicting the pressure variations in the East Texas field.

I have found the application of the instantaneous point sink theory extremely useful in the determination of the pressure build-up in the study of injection wells employed either in salt-water disposal or water-injection programs. In passing, it can be mentioned that the application of this theory lends itself readily to the study of flow-test data from flowing wells, even though the oil is saturated with gas. In another part of this program I have illustrated the application of the diffusivity theory for the calculation of water drive on a field in which reservoir pressure and time are the parameters for the determination of water influx.* Finally the method of superimposing point sinks discussed by Dr. Bruce allows for the qualitative study of different well-spacing patterns, showing the transient pressure distribution in the immediate vicinity of the wells, and offers a means for studying the migration of fluids within the reservoir. I wish to qualify the last statement by saying that the diffusivity theory cannot be expected to apply in its entirety to the flow of heterogeneous mixtures of fluids in reservoirs, but until there is sustained evidence from field data of the validity of the two-phase and three-phase flow theory as hereto reported in the literature, this method offers an approximation as well as a simplified calculation of the more difficult problems encountered in reservoir studies.

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[*] Core Laboratories, Inc.

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* See page 57 this volume.

Analysis of Reservoir Performance

By R. E. Old, Jr.,* Junior Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

Through the use of pressure and production records, formation properties and bottom-hole sample data, the performance of an oil reservoir may be studied analytically to define and evaluate the natural forces acting on and within the reservoir. Use is made of material-balance methods and the equations for natural water encroachment to estimate reserves. Methods for calculation of pressures are given.

A study of the Jones sand, Schuler field, Arkansas, has been made and is given here to illustrate the value of the methods discussed.

Introduction

With the decreasing rate of discovery of new oil reserves, attention is necessarily focused on the efficient development, evaluation, and production of existing reserves. From the nation's viewpoint, the necessity of conserving resources is obvious. From the operator's viewpoint, the problem is to lengthen the period of profitable operation, in an attempt to increase the return on his investment. To do this the operator must take advantage of the natural forces acting on and within the reservoir. Natural water encroachment, the nemesis of profitable operation in the past, can be and is being harnessed to produce a greater oil recovery during the stage of flowing production. Proper evaluation of water encroachment rates and a fuller understanding of reservoir behavior dictate the appropriate production procedures.

Complacency in hit and miss production is obsolete. Oil production must and will approach the efficiency of other businesses, such as manufacturing. A manufacturer will not place an article on the market until he has fully investigated the processes involved, additional investment in equipment, costs of production, and expected profits. These may be modified by actual experience at a later date, but at least he begins with an idea of expected return. It is just as logical that an oil operator should investigate these same factors during the development and the early period of production of an oil reserve.

The complexity of the problems existing in oil reservoirs should not be underestimated. Conversely, they should not be regarded as insoluble. Many completely defy solution, but there are others that can be solved completely or attacked intelligently to yield approximate results.

The petroleum engineer has many tools, both figuratively and literally, at his disposal. Physical data such as core analyses, electrical logs, bottom-hole sample analyses, and bottom-hole pressures are accumulated extensively. Advances in the analytics of fluid flow have kept pace with the advances in measurement of physical data. It is the purpose of this paper to show how some of these records may be analyzed to define certain phases of reservoir behavior.

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MATERIAL-BALANCE METHODS

Material-balance methods have been ably discussed in the literature.[1-4] Many have used these to good advantage; for them much of this paper will seem repetitious. Others, however, have been reluctant to accept these methods fully, believing that the necessary assumptions of either equilibrium or differential liberation of gas from the reservoir oil limit their quantitative application. It has been found from usage that the differences resulting from the two assumptions are minor and may be considered insignificant.

The general equation derived by Schilthuis[1] is as follows:*

$$\Delta n[u + (r_n - r_o)v] + z = n\left[(u - u_o) + mu_o\frac{(v - v_o)}{v_o}\right] + Z$$

With gas or water injection, it is sometimes convenient to express the equation as:

$$\Delta n[u + (r_p - r_o)v] + z = n\left[(u - u_o) + mu_o\frac{(v - v_o)}{v_o}\right] + Z + Gv + Z_i$$

In this form, the left side of the equation is the reservoir volume voided by production. The right side contains the volumes that must fill this void; namely, expansion of oil content and gas cap, water encroachment, injected gas and injected water.

The terms Δn, r_n, z, G, and Z_i represent volumes obtained from field production and injection records. The terms u and r_o are determined from bottom-hole sample analyses. Values of v can be determined directly from a sample of gas-cap material or can be calculated from its hydrocarbon analysis.[5] If samples of gas cap are unobtainable, a close approximation of the volume v can be made from an analysis of casing gas. The value for m can be determined from core analyses and development records.

Adequate logs and core analyses for porosity and content of connate water will give a measured value of n, the oil originally in place. The cumulative water encroachment Z can then be calculated directly. However, in many of the older fields where these data are incomplete, n may be estimated or calculated by material-balance methods.

WATER-DRIVE CALCULATIONS

The solutions of equations for the unsteady-state flow of water into a reservoir for different geometrical configurations have recently been published by Hurst.[6] The radial-drive equations have proved especially applicable. The equation derived by Hurst for cumulative water influx is as follows:

$$\begin{aligned} Z = \frac{2\pi(144)K\sigma HR^4}{5.615\mu\alpha^4} \Big\{ & \frac{P_R - P_1}{\theta_1}[\bar{G}(\alpha^2\theta/R^2) - \bar{G}(\alpha^2(\theta - \theta_1)/R^2)] \\ & + \frac{P_1 - P_2}{\theta_2 - \theta_1}[\bar{G}(\alpha^2(\theta - \theta_1)/R^2) - \bar{G}(\alpha^2(\theta - \theta_2)/R^2)] \\ & + \frac{P_2 - P_3}{\theta_3 - \theta_2}[\bar{G}(\alpha^2(\theta - \theta_2)/R^2) - \bar{G}(\alpha^2(\theta - \theta_3)/R^2)] \\ & \cdots + \frac{P_{n-1} - P}{\theta - \theta_{n-1}}[\bar{G}(\alpha^2(\theta - \theta_{n-1})/R^2)] \end{aligned}$$

It has been found that the values of α^2/R^2 inside the $\bar{G}$ functions are not critical, and that the calculated water encroachment can be considered a function of pressure change with time. For the sake of simplicity, therefore, this equation will be referred to as:

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[1] References are at the end of the paper.

* Nomenclature at end of paper, preceding references.

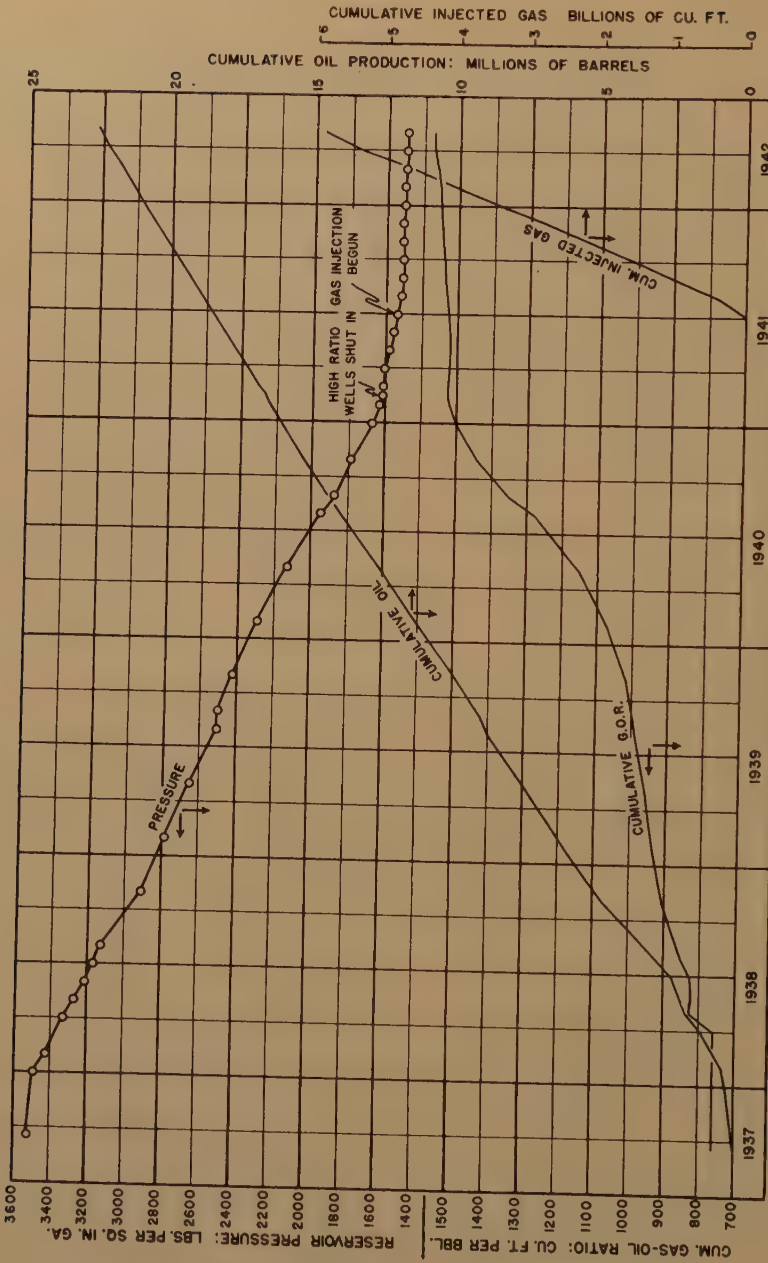

FIG. 1.—PRESSURE-PRODUCTION HISTORY OF SCHULER FIELD, JONES SAND.

$$Z = Cf(P, \theta)$$

where

$$C = \frac{2\pi(144)K\sigma HR^4}{5.615\mu\alpha^4}$$

C must usually be determined empirically in conjunction with the material-balance equation because of lack of complete data on formation properties in the water zone.

In order to illustrate the use of the material-balance equation, the water-drive equation, reservoir formation and fluid characteristics and field pressure and production records, an analysis has been made of the Jones sand, Schuler field, Arkansas.

SCHULER FIELD, JONES SAND, ARKANSAS

The Jones sand of the Schuler field was discovered in September 1937. An impressive amount of data has been accumulated during its development and production.

Pressure declined from an original of 3520 lb. per sq. in. to 1600 lb. per sq. in. by February 1941, when the field was unitized. At that time several wells having high gas-oil ratios were shut in, causing a slower decline. Gas injection was started in July 1941. Since that date the reservoir pressure has remained virtually constant at 1500 lb. per sq. in. Water production has been negligible and probably will continue so for several years because of the practice of shutting in wells when they become wet. The pressure and production records are shown in Fig. 1.

Calculations show that there is natural water encroachment into the Jones sand, but its magnitude heretofore has been insufficient to keep pace with the production of oil and gas. Two methods of determining the amount of water influx are discussed in the following cases.

Case I. Using Geological Measure of Initial Oil in Place

The Jones sand had an original oil zone of 141,500 acre-feet; an original volume ratio of gas cap to oil zone of 0.037; an average porosity of 17.6 per cent and a connate-water content of 35 per cent of pore space as determined from the cores of Marcus No. 3. These volumes provide for 125.6 million barrels of reservoir oil, which corresponds to 86.6 million barrels of stock tank oil initially in place. The essential fluid properties of the reservoir are given in Fig. 2.

The original oil content, bottom-hole sample data, pressure and production records were used to calculate the cumulative water encroachment Z for different times. The results are given in Table 1, and are plotted versus time in Fig. 3. Up to May 1, 1942, about 13 million barrels of water has encroached, while the production of 23 million barrels of stock-tank oil and evolved gas had voided 70 million barrels of net reservoir volume.

Using the physical constants of $R =$ 6400 ft., $K = 350$ millidarcys, $\phi = 0.176$, $= 2.5(10^{-8})$, $\mu = 0.30$ centipoises, with appropriate change in units, α^2/R^2 was calculated to be 0.280. This was used with the pressure-time relations to evaluate $f(P, \theta)$ during the period of production. The value of the function on April 30, 1942, was 54,746 while the cumulative water from the material balance was 13.30 million barrels; therefore, $C = 242.9$. Multiplication of $f(P, \theta)$ by C gives the calculated water encroachments plotted in Fig. 3, which are compared with those calculated by the material-balance equation. The agreement is satisfactory.

Case II. Using No Geological Measure of Initial Oil in Place

Since there is a mathematical relation expressing the proportional variation in Z as a function of pressure and time, Z and n both can be calculated from the pressure-production records and reservoir fluid properties.

The curve shown in Fig. 4 was determined by assuming different values for C.

TABLE 1.—*Material-*

Date: End of Period	Pressure, Lb. per Sq. In. Gauge	Δn, Million Bbl.	u	$(r_p - r_o)$	$(r_p - r_o)v$	$u + (r_p - r_o)v$
1937						
Sept. 17	3,520	0	1.450	0	0	1.450
December		0.346	1.4525	0	0	1.4525
1938						
January	3,420	0.476	1.459	0	0	1.459
March	3,330	1.242	1.4675	0	0	1.4675
April	3,275	1.743	1.4735	69	0.062	1.5355
May	3,212	1.942	1.480	61	0.055	1.535
June	3,169	2.222	1.485	67	0.062	1.547
July	3,125	2.818	1.490	93	0.087	1.577
October	2,910	4.653	1.5173	146	0.146	1.6633
1939						
January	2,785	6.030	1.537	179	0.186	1.723
April	2,650	7.360	1.560	200	0.218	1.778
July	2,505	8.751	1.5887	230	0.265	1.8537
August	2,501	9.011	1.5890	237	0.273	1.862
October	2,425	9.873	1.6080	258	0.307	1.915
1940						
January	2,290	11.259	1.6454	310	0.304	2.0394
April	2,125	12.619	1.6975	440	0.603	2.3005
July	1,950	13.998	1.766	550	0.825	2.591
August	1,878	14.462	1.801	590	0.920	2.721
October	1,785	15.321	1.8495	680	1.122	2.9715
December	1,670	16.132	1.9150	740	1.310	3.225
1941						
January	1,630	16.552	1.940	760	1.383	3.323
Feb. 14	1,609	16.739	1.953	760	1.398	3.351
Feb. 28	1,608	16.929	1.954	759	1.397	3.351
March	1,601	17.348	1.959	756	1.399	3.358
April	1,575	17.757	1.9775	755	1.419	3.3965
May	1,555	18.177	1.9915	756	1.440	3.4315
June	1,537	18.583	2.005	760	1.465	3.470
July	1,514	19.006	2.0225	767	1.503	3.5255
August	1,505	19.426	2.030	772	1.521	3.551
September	1,502	19.830	2.033	774	1.525	3.558
October	1,506	20.249	2.030	777	1.531	3.561
November	1,506	20.652	2.030	781	1.539	3.569
December	1,500	21.068	2.034	785	1.551	3.585
1942						
January	1,498	21.474	2.036	789	1.562	3.598
February	1,492	21.850	2.041	796	1.584	3.625
March	1,493	22.261	2.040	805	1.602	3.642
April	1,493	22.619	2.040	806	1.604	3.644

[a] $r_o = 760$; $u_o =$

Calculations for n were made from each of the last 30 pressure-production points for each assumed value. The deviation of n from the mean value in each series was obtained and plotted against that mean value. The minimum deviation occurs where the mean value of n is 86.5 million barrels, indicating that at this point best agreement is obtained between individual pressure-production points.

The value of n the original oil in place, calculated in this manner is 86.5 million barrels. The remarkably close agreement between this value and the geological measure used in case I may be fortuitous, but it is indicative of the effort spent in the detailed analysis of sand volume and porosity made by the operators in the Schuler field and the Arkansas Oil and Gas Commission. This check also serves to substantiate the connate-water saturation determined from core analysis as well as material-balance method coupled with the unsteady-state water encroachment as a quantitative method for calculating original oil in place.

PRESSURE PREDICTIONS

In addition to defining reservoir mechanics, the material-balance and water-drive equations can be used to predict pressure behavior under different production procedures.

balance Calculations[a]

$\Delta n[u + (r_P - r_o)v]$	Gv	$\left[(u - u_o) + mu_o \frac{(v - v_o)}{v_o}\right]$	$n\left[(u - u_o) + mu_o \frac{(v - v_o)}{v_o}\right]$	Z, Million Bbl.	$f(P, \theta)$
0		0	0	0	0
0.503		0.0030	0.260	0.243	80
0.694		0.0107	0.927	−0.233	192
1.823		0.0205	1.776	0.047	571
2.676		0.0274	2.374	0.302	806
2.981		0.0349	3.023	−0.042	1,182
3.437		0.0406	3.517	−0.080	1,549
4.444		0.0464	4.020	0.424	1,926
7.739		0.0777	6.731	1.008	3,553
10.390		0.1003	8.689	1.701	5,633
13.086		0.1263	10.941	2.145	7,851
16.222		0.1587	13.748	2.474	10,420
16.778		0.1590	13.774	3.004	11,454
18.907		0.1805	15.637	3.270	13,458
22.962		0.2229	19.310	3.652	14,046
29.030		0.2817	24.404	4.626	19,772
36.269		0.3586	31.066	5.203	21,267
39.351		0.3974	34.427	4.924	24.948
45.526		0.4515	39.113	6.413	27,930
52.026		0.5243	45.420	6.606	30,913
55.002		0.5520	47.820	7.182	32,220
56.092		0.5665	49.076	7.016	33,359
56.729		0.5676	49.171	7.558	34,148
58.255		0.5731	49.648	8.607	35,548
60.312		0.5936	51.424	8.888	37,087
62.374		0.6092	52.775	9.599	38,675
64.483		0.6240	54.057	10.426	40,194
67.006	0.730	0.6435	55.746	10.530	41,443
68.982	1.880	0.6517	56.457	10.645	43,625
70.555	3.010	0.6550	56.743	10.802	44,948
72.107	4.207	0.6517	56.457	11.443	45,123
73.707	5.443	0.6517	56.457	11.807	48,259
75.529	6.722	0.6561	56.838	11.969	49,318
77.263	7.933	0.6582	57.020	12.310	51,097
79.206	9.251	0.6639	57.514	12.441	51,919
81.075	10.730	0.6628	57.418	12.927	53,516
82.424	11.708	0.6628	57.418	13.298	54,746

1.450; v_o = 0.000840.

TABLE 2.—*Comparison of Calculated and Measured Pressures after July 1939*

RESULTS PLOTTED IN FIGURE 5

Date: End of Period	Calculated Pressure, Lb. per Sq. In. Gauge	Measured Pressure, Lb. per Sq. In. Gauge
1939		
August	2,489	2,501
October	2,424	2,425
1940		
January	2,279	2,290
April	2,120	2,125
July	1,946	1,950
August	1,907	1,878
October	1,791	1,785
December	1,685	1,670
1941		
February	1,624	1,608
May	1,542	1,555
August	1,494	1,505
November	1,492	1,506
1942		
February	1,486	1,492
April	1,483	1,493

TABLE 3.—*Calculated Future Pressure Behavior*

RESULTS PLOTTED IN FIGURE 6

Date: End of Period	Shut In	Calculated Pressures		
		12,000 Bbl. per Day Oil, 150 Net Gas-oil Ratio	15,000 Bbl. per Day Oil, 150 Net Gas-oil Ratio	20,000 Bbl. per Day Oil, 150 Net Gas-oil Ratio
1942				
April		1,493	1,493	
July	1,492	1,492	1,486	1,492
November	1,527	1,496	1,484	1,478
1943				
March	1,560	1,497	1,481	1,463
July	1,594	1,501	1,477	1,450
November	1,626	1,504	1,471	1,435
1944				
March	1,653	1,501	1,473	1,418
July	1,680	1,498	1,465	1,403

Two methods of handling the mathematics for pressure prediction are possible. One is by differentiation of the material-balance equation and the reservoir fluid properties as functions of pressure. The rate equation for water drive and the balance equation in differential form may be used to project pressure variations. The method of trajectories used in this procedure is an application of the calculus.

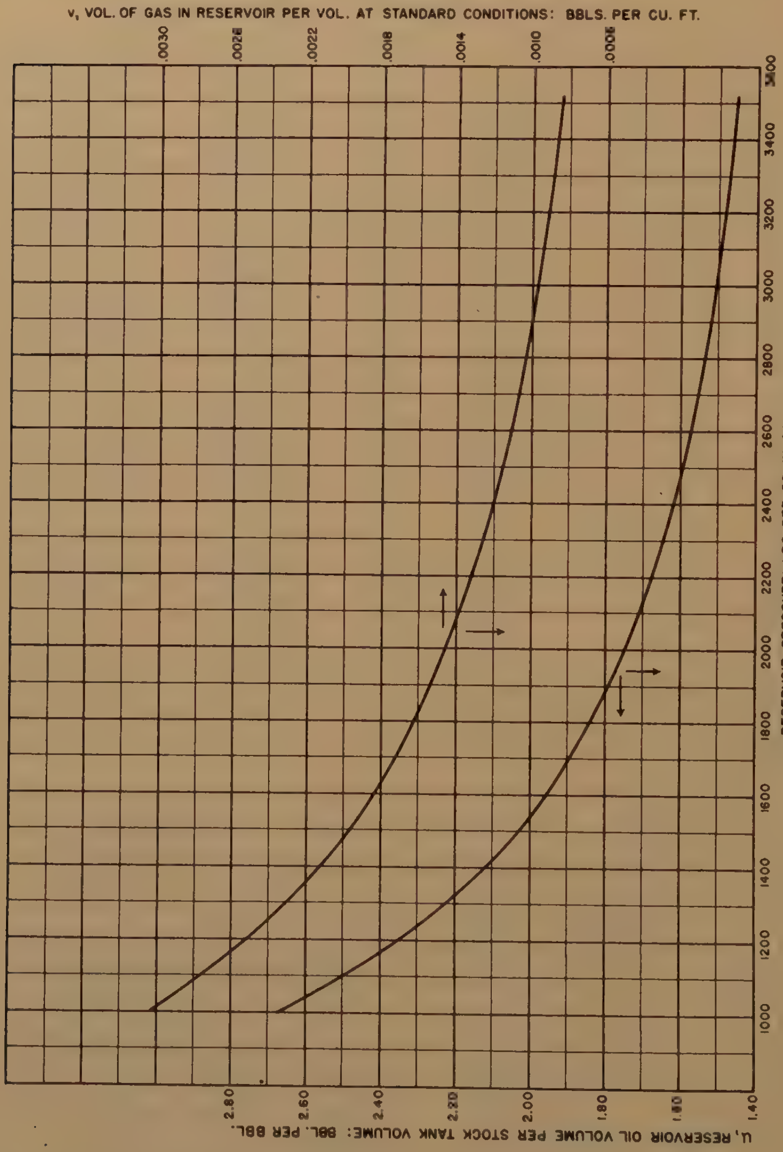

FIG. 2.—VARIATION OF RESERVOIR FLUID PROPERTIES AS A FUNCTION OF RESERVOIR PRESSURE.

The other method, used in this paper, is iteration, or trial and error. Different values of pressure are assumed and substituted in the water-drive equation until a

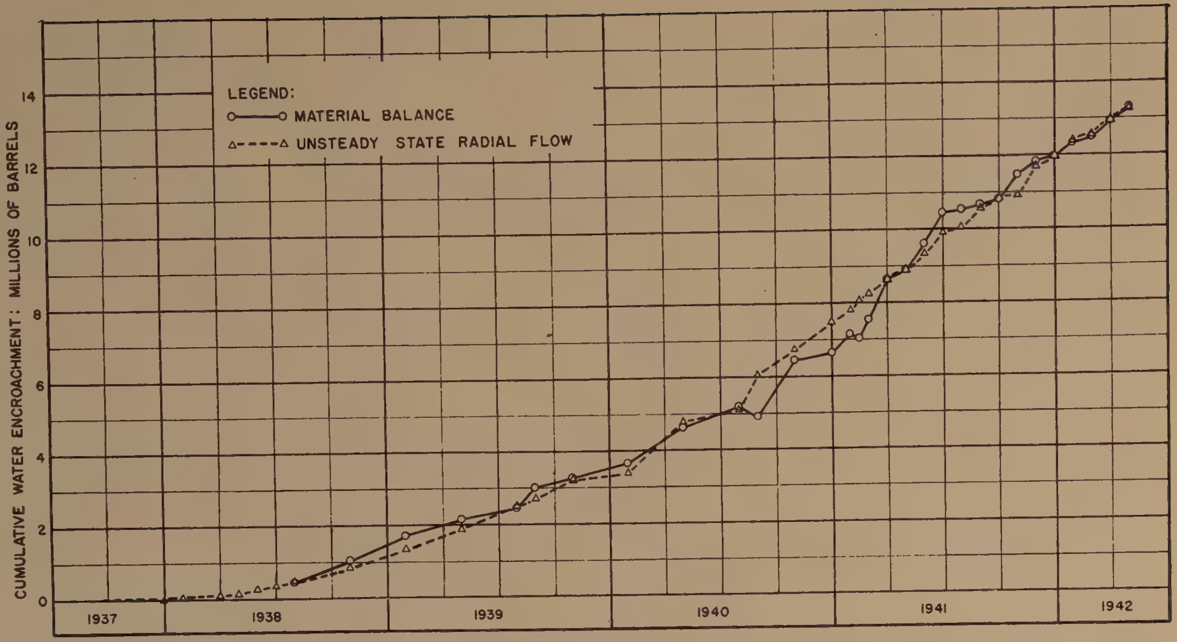

FIG. 3.—COMPARISON OF CUMULATIVE WATER ENCROACHMENT OBTAINED FROM MATERIAL BALANCE AND UNSTEADY-STATE RADIAL FLOW.

value is obtained that will equalize both sides of the balance equation. In use, two or three pressures may be assumed, and the correct one determined by interpolation.

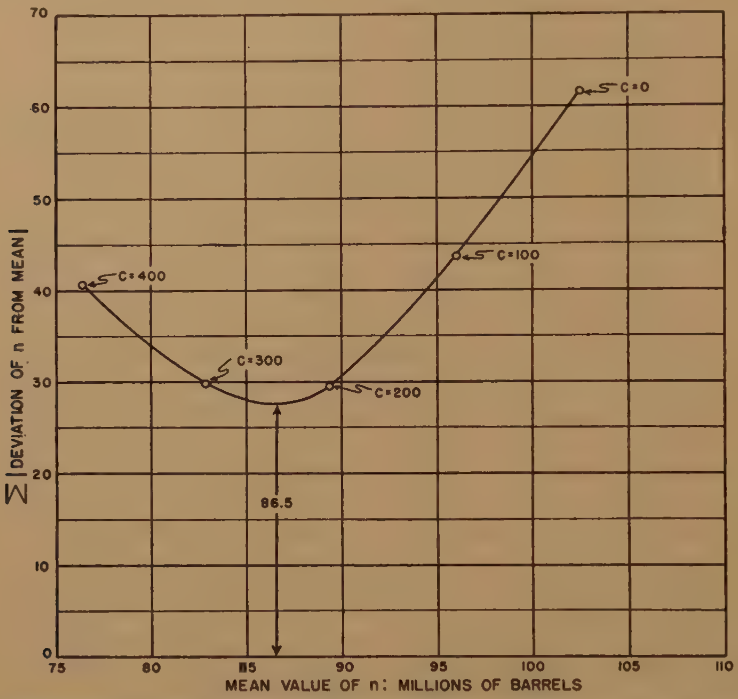

Fig. 4.—Determining *n* and *C* by plotting deviation of *n* from its mean as a function of *n* and *C*.

To illustrate the application of the prediction method, pressure predictions were made from July 31, 1939, based on the history up to that time.

At this date the cumulative water encroachment calculated by the material balance (case I) was 2.47 million barrels, while $f(P, \theta)$ was 10,420. This fixes the value of C as 237.4. Pressure decline using actual production figures was calculated by the method described above. The calculated pressures given in Table 2 and Fig. 5 agree satisfactorily with those measured in the field.

Using the same method, pressure behavior for different production procedures was calculated for the next two years. Rates of 12,000 bbl., 15,000 bbl. and 20,000 bbl. of oil per day with a net gas-oil ratio of 150 cu. ft. per barrel were chosen. It is evident from the pressure trends shown in Fig. 6, and listed in Table 3, that the gas injection is effective in maintaining reservoir pressure.

As a matter of additional interest, calculations were made of the pressure build-up to be expected if the field were shut in. The pressure increase would be slow, rising 187 lb. per sq. in. in two years.

Applications and Limitations

Material-balance calculations are useful in defining reservoir performance when only a small amount of the reserve has been produced. The magnitude of the pressure decline and the number and accuracy of pressure surveys are the controlling factors in applying these methods in the early life of production. They have been applied successfully to fields where only 1 or 2 per cent of the oil in place has been produced. In these cases, precise pressure measurements, porosity and connate water, were available. One important point in the early history of a field is proper averaging of pressures during the development period.

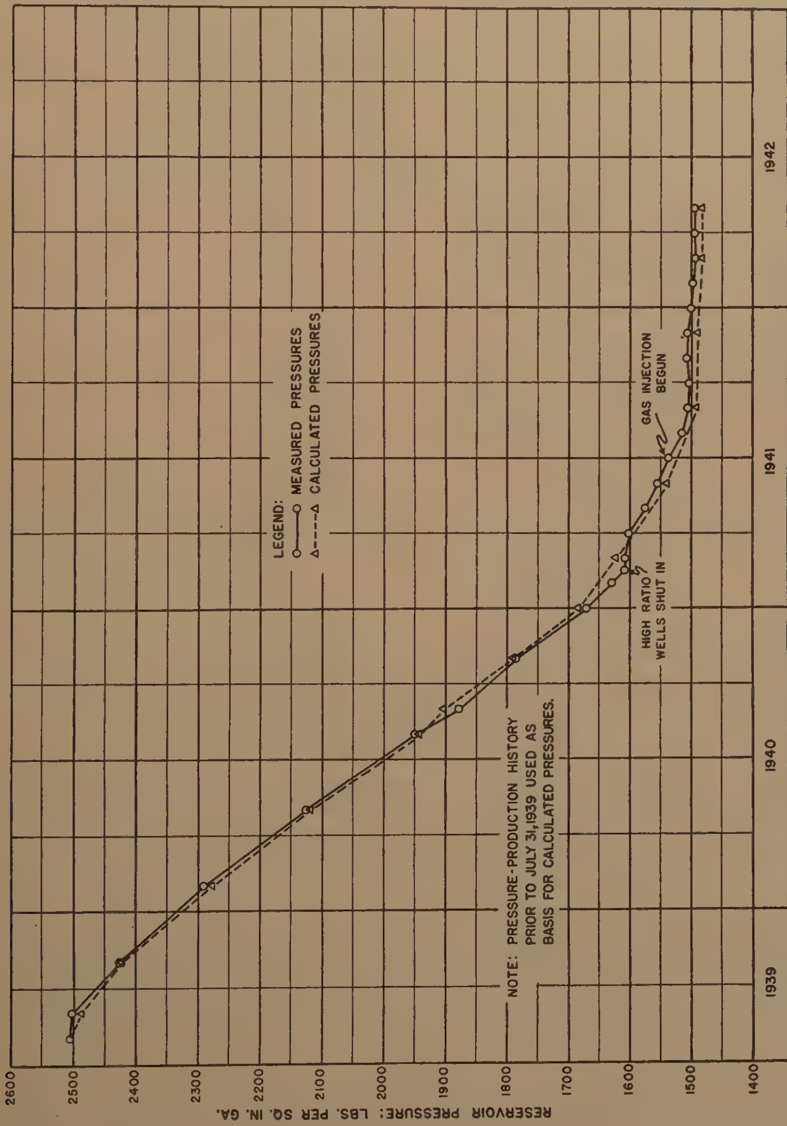

FIG. 5.—ILLUSTRATING AGREEMENT BETWEEN MEASURED PRESSURES AND THOSE DETERMINED FROM CALCULATION OF MATERIAL-BALANCE EQUATION.

In general, application of material-balance calculations are limited chiefly by lack of field data. The greater the number of dependable pressure surveys, the greater the accuracy of results. In the accumulation of field data, it is essential to keep accurate records of gas and water production as well as oil production.

Pressure predictions are limited by the amount and accuracy of pressure-production records when calculations are started.

Pressure data should be obtained only after carefully selected key wells have been shut in for a sufficient period of time for equilibrium to be established. An index of the shut-in time can be observed from build-up or productivity index tests. All wells in the field should be shut in during static bottom-hole pressure surveys unless the test wells are not affected by producing adjacent wells. In many cases, the estimation of future gas-oil ratios may be critical. More research on fluid flow will increase the accuracy of these prediction analyses,

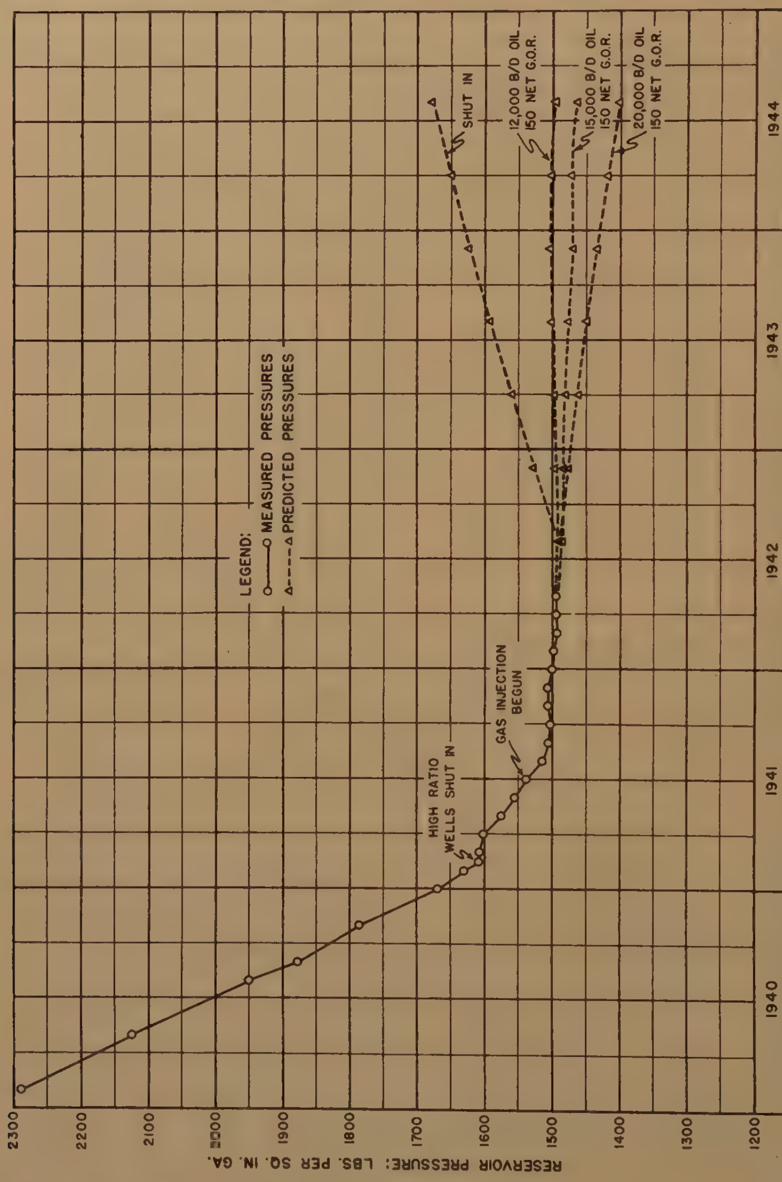

Fig. 6.—Pressure Predictions for Different Assumed Rates in Schuler Field, Employing Material-Balance Equation.

CONCLUSIONS

Quantitative methods have been presented that are applicable for identification and determination of magnitude of water encroachment, determination of initial oil in place, and calculation of pressure behavior in oil reservoirs. The methods are illustrated in a study of the Schuler field, Jones sand. Water encroachment was determined in two different manners (cases I and II), and the initial oil content verified (case II). With two years of pressure-production records as a background, pressure behavior for the following three years was calculated and compared with actual measurements. The satisfactory agreement obtained between the calculated and measured values authenticates the method used.

It is apparent from this and similar studies that the use of the material-balance and water-drive equations when properly applied to field data gives a fundamental tool for evaluation of reservoir performance. One especially important usage is in the determination of pressure behavior. Critical rates of production may be established for water-drive fields. Rates and quantities of injected water to supplement natural encroachment may be predetermined. The effect of gas injection can be known before such program is initiated. Thus the effects of various production programs can be safely evaluated beforehand. When these determinations are combined with core-analysis saturation data, the economics of recovery under each can be analyzed, and the most profitable one selected.

These calculations can be made when reservoir-pressure measurements, production records of oil, water and gas, and bottom-hole sample analyses are known. Determination of structural dimensions using porosity, connate water and permeable thickness from core analyses will aid in earlier application and increased accuracy of results.

The importance of complete and accurate pressure and production records cannot be overemphasized. Reservoir pressure is affected as much by withdrawal of equal reservoir volumes of water and gas as by oil. The extra effort to measure and record these quantities is well justified in view of the increased knowledge of reservoir performance that may be gained by their use.

ACKNOWLEDGMENTS

Appreciation is expressed to the Lion Oil Refining Co. for the release of the connate-water figure and to the Arkansas Oil and Gas Commission and Schuler Unit Committee for the copious amount of data made available for this paper.

Acknowledgment is made to Nelson W. Williams, who assisted in the calculations and preparation of the curves and to Mr. James A. Lewis, whose helpful suggestions and criticisms were invaluable.

NOMENCLATURE

n, stock-tank oil originally in place, bbl.
Δn, stock-tank oil produced, bbl.
u, volume of oil and originally dissolved gas in reservoir per volume of stock-tank oil.
u_o, original value of u equal to 1.450 for Jones sand oil.
r_n, cumulative net produced gas-oil ratio, cu. ft. per bbl., at 60°F. and 14.7 lb. per sq. in. abs.
r_p, cumulative produced gas-oil ratio, cu. ft. per bbl., at 60°F. and 14.7 lb. per sq. in. abs.
r_o, originally dissolved gas-oil ratio, cu. ft. per bbl., equal to 760 for Jones sand oil.
v, barrels of gas in reservoir per cubic foot at standard conditions.
v_o, original value of v equal to 0.000840 for Jones sand.
z, barrels of water produced.
Z, total barrels of water encroachment.
m, original volume ratio of gas zone to oil zone.
G, total gas injected, cu. ft. at standard conditions of 60°F. and 14.7 lb. per sq. in. abs.
Z_i, total water injected, bbl.
P_R, original reservoir pressure, lb. per sq. gauge.
P, reservoir pressure, lb. per sq. in. gauge.
K, permeability, cu. ft. per day per sq. ft. per lb. per sq. ft. per ft.
c, compressibility, cu. ft. per lb. per sq. ft.
ϕ, porosity, fraction.
α^2, diffusivity, sq. ft. per day equal to $\frac{K}{\mu\phi C}$.
R, radius of reservoir, ft.
H, sand thickness, ft.
θ, time, days.
σ, fraction of perimeter of field exposed to water encroachment.
μ, viscosity of water in formation, centipoise.

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DISCUSSION

(*C. H. Keplinger presiding*)

R. C. CRAZE,* Houston, Texas.—Through application of field and laboratory data to the material balance and unsteady-state equation for the flow of water into a reservoir, the author has demonstrated in a clearly defined pattern the procedure followed in computing quantitatively the relation between the pressure behavior and the withdrawal of fluids from the producing horizon, not only for the history of the field cited but also for predictions of pressure in the future under various assumed operating conditions. Emphasis is placed on the importance of available, complete, and accurate reservoir-pressure data, production records, subsurface sample data, and structural information, in order that a reliable interpretation of the forces acting in a reservoir may be possible.

Discussion of the utility of an analysis of reservoir behavior suggests the following additional thoughts which are not covered in the paper:

Application of the material balance and unsteady-state equations to the evaluation of reservoir performance not only permits calculation of past reservoir-pressure behavior and predicted future pressure trends, but also evaluates directly the behavior of the gas cap and the relative changes in the volume of the oil zone throughout the period under consideration.

In conjunction with the calculated gas-cap performance, inspection of gas-oil ratio behavior in individual wells may disclose changes in the gas-oil contact that will correlate with that computed from pressure-production relations.

Complementing the determination of the water influx by pressure-production analysis, a study of the history, structural location, and behavior of wells producing water may be made in an effort to estimate the volume of sand flooded by water encroachment and the attendant rise of the water table. Correlation of this independent analysis with the calculated water influx may yield more reliable information on the flooding efficiency of the water drive, and permit prediction of future rise of the water. Such information is useful in anticipating future production problems in individual wells.

The correct interpretation of the results obtained from a study of the reservoir performance carried out in the manner described in the paper must be accompanied by considerable caution, and by an appreciation of all actual field data that might contribute to a better understanding of the reservoir behavior. Particular attention is directed to the empirical evaluation of the constant C where

$$C = \frac{2\pi(144)K\sigma HR^4}{5.615\mu\alpha^4}$$

Care must be exercised that the determined value for C does not indicate values for the individual component parts that represent magnitudes beyond reasonable ranges for those factors.

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Reservoir Analysis and Geologic Structure

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(Los Angeles Meeting and Austin Meet'ng, October 1942)

Abstract

The engineer and the conservationist agree that effective water drive is the desirable reservoir production mechanism. Water drive may result either from the expansion of edge water, the reservoir water bordering an oil pool, or from the artesian flow of edge water from the outcrop. Thus, the extent of the reservoir has an important bearing upon both the rate and the ultimate quantity of water influx to an oil pool.

Lens-type reservoirs are generally recognizable, but the complete structure of the more important domal types, having possible limitations from crestal and synclinal faulting, is not well understood. The delineation from cores, electrical logs and exploitation phenomena of the crestal portions of reservoirs is increasingly exact. This paper suggests that inference from these factual pictures, combined with the scattered well and geophysical data of the synclines and with consideration of the dynamics of structural formation, may be applied to solving the complete geologic structure. Since faulting on the domes and in the synclines may effectively seal and thus limit the size of a reservoir and bar additional water influx, consideration of geologic structure and its possible effects is essential to complete analysis and prediction of reservoir performance.

Introduction

Implicit in reservoir studies is the fact that the oil must be displaced from the reservoir rock by some other fluid, either gas or water, and this understanding yields the terms descriptive of the major reservoir production mechanisms, gas expansion and water drive. Three recent papers[1,2,3] make clear the economic and conservation preeminence of water drive as a production mechanism; in fact, the title of the latest of these is "Production under Effective Water Drive as a Standard for Conservation Practice."

There appears to be an assumption at times among analysts that the effectiveness of a water drive is solely dependent on the rate of oil production; that is, if water drive appears to be insufficient or lacking, a lower oil-recovery rate would increase or reveal it. This assumption might result from the fact that the analysis has been wholly developed during the period of production curtailment; that is, since 1929. The writer takes it that the recurrent phrase in De Golyer's paper,[3] "some degree of water drive," is related to this assumption. In California, an extraordinary phrase, "inactive water drive," is rather common and the connotation of uncertainty regarding our knowledge of reservoir performance is evident.

Wyckoff[2] speaks of the type of reservoir and performance as follows: "In general, reservoirs may be any one or a combination of domal, faulted, lenticular, or stratigraphic traps. Insofar as the dynamic performance of such reservoirs is concerned, the particular type merely determines whether regional flow is symmetrical as in a uniformly developed domal or lenticular type, or one-sided as in many stratigraphic or faulted traps." But whether the flow is

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[1] References are at the end of the paper.

symmetrical or asymmetrical, all mathematical formulations of performance, following the work of Hurst[4] and Muskat,[5] assume a reservoir of large or infinite extent.

A further introductory point of importance is the prolongation of the life of oil fields under proration to many years, to even 30 or more,[6] and thus the empirical check of theory and future performance prediction is sometimes made from but a small segment of the pressure-production-time relation, which embodies a pool's history. Under precurtailment production practice, the flowing life was only a few years, but it is usually impossible to investigate such compact pool histories in the light of present knowledge, because few if any of the properties and performance data of the reservoir and its fluids were recorded.

The present inquiry was undertaken as an examination of the phrase "degree of water drive," and immediately involved the nature and extent of the regional flow postulated by the analysts. Many reservoirs are so limited in continuity, in size, by depositional or structural features, that the term "regional" should hardly be applied to flow within them. While reservoirs of the lens type are rather readily recognized, reservoirs having structural limitations to the amount and to the continuous advance of edge water have not been adequately described in the literature. The writer wishes to call attention to reservoir structure and to suggest that its delineation is necessary if the complete production mechanism of a reservoir is to be understood or anticipated.

Water Drive

In the limiting cases, the mechanism of a water drive is either that of the expansion of a compressed liquid or of the simple artesian flow of a liquid so slightly compressed as to be essentially nonexpanding. Expansion must initially be effective in all reservoirs but can be of great importance as an oil-producing force only where the total volume of edge water is large. The expansion concept was developed in studies of the East Texas field,[4,5,7,8] and that field is a documented example of its importance. An artesian water drive requires that flow of water shall take place through the entire reservoir, from outcrop to oil interface. Production from the Mexican fields is commonly ascribed to the artesian flow mechanism but consideration indicates that there, too, water expansion may have been the productive force. This seems an academic distinction, for in reservoirs of such great permeability, artesian flow probably could occur at rates that would have maintained the reported pressures.

In a lenslike reservoir, artesian drive cannot exist but expansion water drive can occur. If a blanket reservoir is cut by faults and the reservoir face is sealed at the fault planes, the seeming blanket reservoir will perform as does a lens-type reservoir. Consideration of the kind of reservoir, its total size and average permeability, then, are necessary to define a pool's performance or "degree of water drive." Where these seem to be sufficient, other factors are the oil-production rates yielding proper pressure maintenance under either expansion or artesian water drives. If these oil rates are so low as to be uneconomic, a pool may be produced by gas expansion without recognition of a water drive. Because water drive is the desirable production mechanism, engineers and conservationists urge[3] that each new pool shall be initially developed and produced so as to make a water drive effective until it is proved that such operation is uneconomic.

It is accepted that artesian flow in the Woodbine zone could not have maintained the pressures of the East Texas field at current or past oil-production rates. Further, it is possible that artesian flow cannot occur, or is greatly restricted, in the Woodbine, because the reservoir may be limited in size, cut off from the outcrop, by the fault system to the west and north (ref. 7, Fig. 2). There is some evidence of this at Mexia-Powell, where salt water is found in the Woodbine east of the faulting and fresh water on the west side. However, the Woodbine in the East Texas basin—that is, within this fault system—is a blanket sand of uniform character and, even if the other structures in the basin are considered as plugs or islands and subtracted from the total in a calculation of the amount of water available, it still appears that it probably constitutes a continuously permeable blanket of sufficient size to produce the East Texas field to exhaustion by expansion water drive.

Simple artesian flow has an unquestioned physical basis. However, to the writer's knowledge, no well-documented history exists of a pool where an important part of its production resulted from artesian water drive. The number of studies of expansion water-drive pools steadily increases. The fact, as stated by De Golyer,[3] that " . . . the original reservoir pressure . . . in most reservoirs is approximately that of the hydrostatic head of water for the corresponding depth . . . ," strains the belief that artesian drive actually exists in many pools. When the number of flowing artesian water supplies is recalled, it is striking that no similar condition in petroleum reservoirs, in which original pressure exceeds the hydrostatic head from the surface, is common.

In a humid area, as in Mexico or Burma, replenishment of water at the outcrop might be sufficient to equal reservoir withdrawals in an oil pool under artesian drive and a constant pressure in the pool during production would be noted. However, in a pool in an arid area, like the San Joaquin Valley of California, reservoir withdrawal would be at a greater rate than reservoir replenishment and a declining pressure in an oil pool under artesian drive would be present. With such structures, there should frequently be enough water in the monocline off the outcrop, and lying at an elevation above the crest of the oil pool, to yield a definitely advancing edge water. Some of the fields here discussed have been mentioned as examples of this type of artesian water drive but the observed limited edge-water advances in these fields again imply that free flow from outcrop to oil-water interface seldom exists in a reservoir stratum.

LENS-TYPE RESERVOIRS

Many reservoirs are limited in size by depositional or structural features. These limitations preclude or impede artesian water flow within the reservoir, and in such pools only the expansion water drive can be operative. Change of facies within a horizon up and down dip from a field, as exemplified in certain Jackson-Eocene pools of the Laredo district of Texas, gives an example of a limited reservoir, the absence of artesian water drive, and an expansion water drive of so small an amount as to pass unrecognized.

RESERVOIRS WITH STRUCTURAL LIMITATIONS

The structural limitations of reservoirs to the amount and to the continuous advance of edge water are of great importance, since they exist in many fields. No satisfactory explanation of the failure of edge water to advance continuously in the fields of the west side of the San Joaquin Valley of California has yet been presented. Pack[9] suggested reaction between oil and edge water, and Wilhelm[10] deposition of salts from edge water, at and near the interface, to lessen or destroy permeability. Also, Herold used the Jamin effect to explain the failure of encroachment.[11] Research[12] is now being directed at the presence or development of hydrophobic surfaces as the cause of, or an influence on, nonencroachment. The explanation proposed here is that, since the structural breaks surrounding a pool limit the effective size of the reservoir, the productive mechanism of the fields in question passed directly from expansion water drive to gas expansion.

From the earliest petroleum exploitation, the correlation of well logs to delineate subsurface structure has been a difficult problem, especially in the fields producing from Tertiary sediments. Until recent years, the almost universal picture of high-relief producing structures has been one of even folds with blanket sands extending over and around the pools, smooth and unbroken. Inherent in this concept is the adjustment of the sediments to folding by flowage or by the gliding of the strata along bedding planes.[13,14 p. 55]

Since the introduction of the core barrel by J. E. Elliott in 1921, and the application of electrical logging beginning in 1932, the factual knowledge of the subsurface has increased enormously. From the fault patterns delineated in the structures of the Gulf Coast of Texas and Louisiana and the San Joaquin Valley of California, it is an evident generality that the clastic sediments, including the most recent, adjust themselves to elementary folding by faulting alone. Modern detailed surface mapping, such as Galloway's[15] in Kettleman and that recently done in the Elk Hills, has contributed to this knowledge, as have also the geophysical exploratory techniques and inferences from certain exploitation phenomena, such as reservoir performance.

The tension fault pattern and the neutral zone in the competent folds of the San Joaquin Valley[15] have been delineated and the presence of the compression fault pattern in the lower measures of these folds is indicated.[16] The tension fault pattern in the Conroe-type, incompetent folds of the Gulf Coast is well known. The anticlines of the west side of the San Joaquin do not occur by themselves, for two accompanying synclines, having fault patterns complementary to those in the anticline, are also present. The complete structure of the piercement and the semipiercement domes of the Gulf Coast includes the dome and the accompanying rim syncline. In the deep-seated domes, the notable tension fault pattern of the dome must be complemented by the related synclinal pattern surrounding the dome. From the foregoing considerations, Figs. 1 and 2 are presented as diagrams illustrating some features of elementary structures.

In the main, synclinal fault patterns must be inferred and cannot be delineated from well logs, because wells are drilled in synclines only by accident. With Gulf Coast structures (Fig. 2), the synclinal fault pattern in the upper strata is narrow, the thin end of a wedge. This, with the effects of sedimentation and erosion during structural growth and of regional dip, requires many control points before delineation can be attempted. In synclinal areas, the lack of control from wells is generally equaled by the paucity of geophysical data, for detailed measurements with gravity and seismograph instruments are in general localized on the structural highs; also, deep reflections or events are seldom calculated. However, scattered geophysical data do support the structural picture presented here; for example, the faulted syncline, valleyward from Kettleman, is plainly noted in seismograms.

Fig. 1 illustrates the type structure of the fields of the west side of the San Joaquin Valley. The central anticline can represent Kettleman North Dome with its Temblor-Miocene producing sands crossing the structure in the neutral zone, unfaulted, and its Avenal-Eocene sands cut by the faults of the compression zone. In the Kettleman Plains syncline, to the southwest, the synclinal, tension-fault pattern cuts both these formations; and this is true also in the faulted syncline on the valley side. Comparison should be made with Woodring[17] for the presently accepted, conventional cross section of such structures. He displays the Temblor formation sweeping from the outcrop in Reef Ridge down under the plains, over the dome and down under the valley, smooth and unbroken.

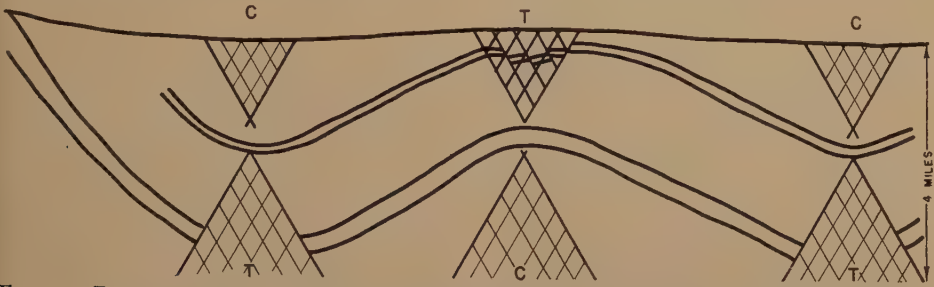

FIG. 1.—DIAGRAMMATIC STRAIN AND FAULT PATTERNS OF COMPETENT, COMPRESSIONAL-TYPE STRUCTURES.

T, tension patterns; C, compression patterns. Horizontal and vertical scales are the same.

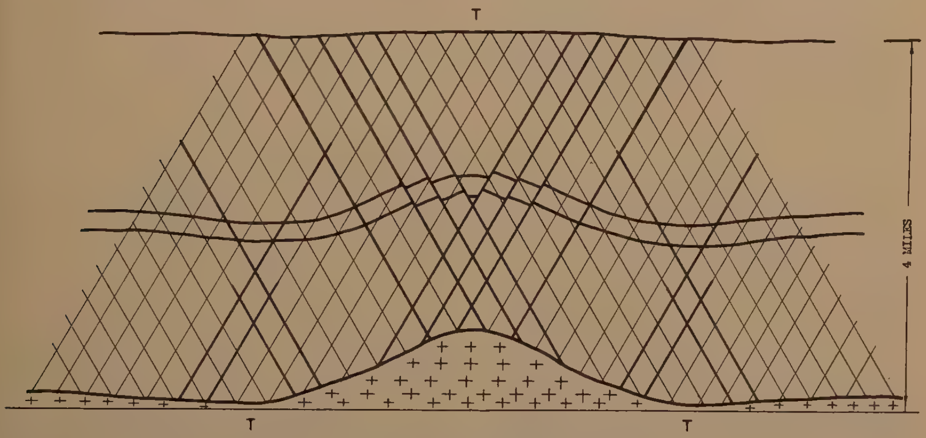

FIG. 2.—DIAGRAMMATIC STRAIN AND FAULT PATTERNS OF INCOMPETENT, GRAVITATIONAL-TYPE, DEEP-SEATED STRUCTURES.

T, tension patterns. Horizontal and vertical scales are the same.

From the deep-seated dome diagram (Fig. 2), it is evident that the salt uplift is several times as high as the depth of the trough in the salt in the syncline. Nettleton (pp. 89–92 of ref. 18) has exhaustively discussed the geometry of different types of salt domes and gives a ratio, H/t, between the height of the salt and the thickness of the salt bed, between 4.9 and 42.7 from the calculations for nine domes of different assumed proportions. Plainly, the synclinal faults will not have the displacement of the domal faults. No data are available to answer the question whether the fault planes contain gouge or salt deposits sufficient to prevent or impede fluid passage in a sand bed cut by them. Another question is whether the synclinal faulting reaches to the surface, or at least to a point, for example, above the Frio sands in the syncline around Hastings. This also cannot be positively answered but the inference here maintained, from the concept that the sediments respond to adjustment by fracture, is that it does.

Objections to these formulations should be recalled: With compressional structures can the tensional faulting postulated at depth in the synclines occur and in gravitational structures is the synclinal faulting so minor as to not effect reservoir discontinuities?

Paul Weaver has suggested to the writer (in a personal communication) that the regional tension faults of the Gulf Coast, as distinguished from the faulting in and around a structure, are sufficiently numerous to give definite limits to the reservoirs of all Gulf Coast pools without resort to the possibly questionable limitations of synclinal faulting.

In general, the hydraulic pressure within a zone has adjusted itself across the structural breaks during geologic time, as in Kettleman North Dome and in the East Texas field. But the problem that here concerns us is the possible lag in adjustment during the relatively few years in the life of an oil field.

GEOLOGIC STRUCTURE

This paper is not monographic but its main thesis is that the synclinal fault patterns can be inferred from the known domal patterns and a structural dynamics might properly be outlined as the connective. Physical analysis of most structures is difficult because of the complexity of the stress patterns, our lack of knowledge of the mechanical properties of the deformed materials and the impossibility of uncovering all necessary facts. A geologic structure in the making is a dynamic system with the application of the forces continuing after the materials have failed and their configuration has changed. Sufficient outcrops for the observation of many structural facts are generally present only in advanced structures. The depth of burial at the time of folding of a formation that is now exposed is difficult to estimate, but this is critical to the determination of the mechanical properties of the materials folded.

It is submitted that the oil-field structures that are studied here represent infant diastrophism and that their stress patterns and materials performance are elemental. Also, the delineation of such structures by cores, electrical logs, and the geophysical techniques, and by inference from various phenomena in exploitation is rather positive, although it also is never complete. The writer thinks that some geological concepts cannot be applied to the structures here treated. For example, Hubbert (p. 1463, ref. 19) has written that rocks are capable of " . . . folding plastically as even quartzites in the Appalachians are known to have done, . . . " and later (p. 1485, ref. 19) that, "There is much evidence to indicate that rocks are elastico-viscous materials of very high viscosity." Also, Willis (p. 55 of ref. 14) has written: "It was once the prevailing belief that anticlines must split open along their axes in order to accommodate the tensile stress set up by bending, but it is now understood that the adjustment usually takes place in consequence of the gliding of the strata on the bedding planes." As previously stated, the evidence for the adjustment of the strata by faulting seems conclusive for elemental structures in the depth range considered. Even the bent Temblor sandstone in the neutral zone of Kettleman North Dome shows in cores much minor faulting with calcite fillings and slickensides.

STRUCTURE OF THE TYPE OF THE GULF COAST OF TEXAS AND LOUISIANA

The deep-seated structures are represented in more advanced form by the semipiercement and piercement salt domes. Aside from salt-dome structures, the important regional structural feature of the Coastal Plain is the tension fault. Some of these faults are known to be of great length and throw and to extend across local structures, both domes and other faults. Most of these faults, those mapped or delineated in the subsurface or indicated from geophysical data, are strike faults trending parallel to the coast line (p. 264, ref. 20) and dipping toward the Gulf with the Gulfward side downthrown. Also, scattered observations (*idem*) indicate the existence of a less prominent fault system having trends diagonal to the present coast line.

The fault-type field of the Gulf Coast, such as Amelia, represents elementary structure. The regional tension fault is the primary feature; the sediments will not support an open crack and the strata on the down-dropped side fail and slump against the fault. This slumping results in the kind of domal closure of the strata that is found in such fields.

In Fig. 2, all the faults are constructed at approximately a 60° angle. In Gulf Coast, deep-seated, elementary structures, the dip of the fault planes in the dropped, domal portion should be approximately 60°. The regional tension faults of the province dip toward the Gulf at approximately 60°. It is understood that the faulting in semipiercement and piercement domes is excluded from this discussion, and it should be recalled that even Hastings, with uplift exceeding 1000 ft., is a somewhat advanced structure.

It is not to be presumed that Fig. 2 completely represents an actual structure. There is a divergence of the younger beds from successive cycles of sedimentation and structural growth, and the strain rhombs at depth may step inward to cover a smaller area in plan in successively younger beds.

The Coastal Plain is subjected to tension stresses from sedimentation (loading) downdip and variations in sedimentation (loading) along the strike and its faulting (failure) results from shear. An analogy is with a great beam, relatively thin and lying on a poor soil; loading toward one end causes the soil foundation to shift (adjustment in the geosyncline) and the failure of the beam in shear. The diagonal faults result from shear stresses set up by lateral variations in the sediments of the Plain. The reason that displacement occurs on the faults is that the sediments will not tolerate an open crack. It is noted that the secondary failure is also in shear and at approximately the 60° angle.

There is some evidence that some Gulf Coast faults are, in section, step faults with relatively planelike surfaces in some sandy members and complex breakage (the stepbacks) in some shales. The delineation of such a fault would require extremely close well spacing. The mechanics presented here do not require that all faulting shall extend to great depths. The testing of materials is made difficult by nonhomogeneity and resulting random breaks. It should not detract from this presentation to state that there should be some faulting, having rather positive delineation, that diverges from the type.

Following the Nettleton hypothesis,[18] it is generally accepted that the salt domes of the Gulf Coast have grown because of the difference in density between the salt and the surrounding sediments and that the salt has acted as a highly viscous fluid. The further development of the hypothesis, that the surrounding sediments have also acted as fluids, is not generally accepted and of course is not in accord with this presentation. After the salt bed has been sufficiently covered by other sediments, the energy to make a dome is present but it is potential energy, energy of position, and a mechanism for its release is necessary. The release that is suggested here is the regional tension fault. A regional tension fault could hardly occur without transverse adjustments or faulting; also, it will intersect faults of the patterns diagonal to it. Such intersections can provide the localization of growth of the salt as a dome rather than as a ridge or salt anticline.

STRUCTURE OF TYPE OF WEST SIDE OF SAN JOAQUIN VALLEY

The Kettleman Hills are representative, and because surface exposures are good and the mapping recently done, and the exploitation has been carried out with most of the modern tools, the structure can be discussed rather factually. Two sets of faults are exposed in the Kettleman North Dome, strike faults and diagonal faults, and Woodring writes of them as follows:

> More than half of the faults in North Dome are strike faults that trend about parallel to the axis of the anticline. The strike faults, which are about equally numerous along each side of the axis, have displacements ranging from a few feet to about 300 feet. Most of the strike faults dip toward the axis at angles that average about 60°. A few on each side of the anticline, however, dip away from the axis of the anticline at angles that average slightly more than 60°. (p. 150 of ref. 17.)

A field observation, omitted by Woodring, should be included here. In cross section, the tension complex appears as a wedge (ref. 15, Fig. 6) with its apex in the McClure shale at about 5000 ft. below sea level. Also, the regularity of the Temblor surface indicates that it lies in the neutral zone of the fold, that there is a "neutral zone" present.

> Normal faults of the second set have displacements of less than 100 feet. They trend slightly east of north and cross the axis of the anticline, and the general strike of the strata at angles of about 60°. These faults may be referred to as diagonal faults. Diagonal faults, which are present along the axis of the entire anticline except the extreme ends, are most numerous in zones surrounding the area near each end where pronounced plunge of the axis begins. Most of the diagonal faults on and near the plunging ends of the anticline dip in the general direction of the plunge at an average angle of about 60°, but a few of the faults dip in the opposite direction. (ref. 17.)

Woodring also writes of the origin of the structure (p. 152, ref. 17):

> The deformation of the Kettleman Hills is attributed to compression in a north-south direction applied to a northwestward-trending zone of weak strata in which echelon anticlines were being formed. The upward squeezing of incompetent material lifted and folded the strata; the faulting is attributed to shearing that accompanies differential vertical stresses in competent strata overlying the rising incompetent material.

A formulation more in accord with the present discussion should be considered. The deformation of the Kettleman Hills has resulted from tangential compression and the internal force, the weight of the sediments. As the deformation is in an early stage, the adjustment of the strata to it was accomplished by the sawbuck faulting of the anticlines and synclines. The diagonal tension faulting is attributed to beam stresses on the regional structure. A complete formulation would consider the situation at depth where the fault patterns of the anticlines and synclines join and the folds either sharpen or disappear.

To the writer's knowledge, the tension pattern, the upper half of the sawbuck, has been mapped in but four anticlines. Surface mapping shows it to be in Kettleman North and Middle Domes and in the Elk Hills and subsurface delineation reveals it in the Elk Hills and in the Buena Vista Hills. Possibly, however, the best argument for its widespread occurrence is the widely occurring surface-drainage patterns resulting from main drainage following anticlinal axes, and this suggests that erosion frequently has removed portions or even much of the sawbuck patterns. The presence of the neutral zone is established, of course, in Kettleman North Dome.

The Ventura Avenue structure of California is somewhat advanced. It is interpreted as having most of the upper half of the sawbuck pattern eroded away, the neutral zone is near the surface and the compression member of the sawbuck, with its reverse faulting, has been delineated in exploitation.

Further, as to the presence of the compression pattern at depth, Willis (p. 251, ref. 14) has written that " . . . there must be relief from load within a competent arch, under the competent . . . (zone) . . . the underlying strata . . . are often broken, crumpled, and confusedly overthrust." The writer recalls that the presence of reverse faulting in the deeply eroded Rumsey Hills structure of central California has been mentioned to him. McMasters[16] mentions erratic, steep dips and reversal of direction of dip in the cores between 10,000 and 12,000 ft. of the recent 14,622-ft. test of the Buena Vista anticline. That the well was properly located for a test along the axis is attested by the uniformly low dips, from 4° to 15°, encountered to 10,000 ft. Close well spacing is required for good delineation of fault patterns, and the deep reservoirs, which would have compression faulting, have been drilled with wide spacing. Anomalies in reservoir-pressure patterns, between individual wells and groups of wells, may then be the best key to the presence of the faults. Such indications have been noted in the deep Wagonwheel zone of North Belridge and should be looked for in the Avenal of Kettleman North Dome as its development advances.

PERFORMANCE OF SEDIMENTS AS MATERIALS

The usefulness of this paper will be increased if a physical basis for the failure of the strata in tension can be suggested.

If the sediments are considered to be brittle materials, failure near the surface would be expected in tension alone and at an angle of 45°. At depth, where the weight of the sediments introduces shear, the failure plane would steepen because of friction within the sediments themselves. The shear angle (p. 451 of ref. 21) is expressed as $45° + \frac{\phi}{2}$ where ϕ is the angle whose tangent is the coefficient of friction. It is recalled that for the sediments of the Coastal Plain and the west side of the San Joaquin, ϕ is approximately 30°.

However, if the sediments en masse perform as ductile materials, they will, under tensional stress, reach the elastic limit in shear and fail before the elastic limit in tension is reached (p. 450 of ref. 21) and thus the tension break near the surface will be close to 60° rather than 45°. The evidence on this point, the angle of dip of near-surface faulting, is not good. In Kettleman, erosion has removed upper beds and in the Gulf Coast the shallow beds are rarely studied in petroleum exploitation. It is therefore almost mere opinion to say that it is expected that evidence will be found to support the concept that the sediments en masse in the two areas studied have performed as ductile materials. However, the practical point is that at depth the angle toward 60° should be expected, regardless of the question of brittleness or ductility. And where faults are studied at shallow depth, the establishment of the dip angle factually would be important to any structural generalization.

With the foregoing, reference should be made to W. H. Bucher's mechanical interpretation of joints.[22] The joint system in a very minor structure at Mine Fork, Kentucky, was delineated. The structure can be considered to be an incipient anticline. The shearing of the sandstone resulted from simple tension and analysis led to an analogy with shearing in ductile materials.

APPLICATION

This discussion is not, however, an academic one. If its concepts are sound, it explains the productive mechanism of all or most of the pools of the west side of the San Joaquin Valley, one of the world's greatest producing areas.

It is evident that the writer believes that Kettleman North Dome will prove to be a pool having only an expansion water drive, artesian drive being precluded by the inferred synclinal faulting. Production has not yet been sufficient to completely support this. Another point can be made sa to the faulting—a well-defined break in observed reservoir pressures between the north and south end areas of the pool has developed during production. This is attributed to reservoir discontinuity effected by the diagonal faults, and it is noted that these faults, having resulted from beam stresses, can extend to great depth.

The west-side fields such as Kettleman North and Middle Domes, North Belridge and the pools of the Midway-Sunset-Elk Hills are considered to belong to the general structural type illustrated in Fig. 1. Many of these pools are depleted, with gravity flow now the essential productive force, but none of them has a rim of abandoned, water-captured wells. Their productive mechanism can be illustrated by that of the Buena Vista front pool, mentioned by Wilhelm.[10] The pool produces from two Etchegoin-Pliocene sands (a zone about 110 ft. thick) which buttress on the Buena Vista anticline and extend as thickening blankets northeast into the Buena Vista syncline, fronting the Elk Hills. The unbroken body of edge water extends along the 10-mile front of the pool like a blunt wedge with a width of 1½ miles to the west and 5 miles or more at the east. A few outpost wells were drilled into water, and these and their immediate neighbors were captured by advancing edge water. Also, a water-embayment updip in the direction of the long produced section 32, T.31 S., R.24 E., M.D.B. and M. area became apparent from outpost drilling. The advance of edge water, however, stopped suddenly and no more wells have gone to water in 15 years. A structural interpretation of this break in the pressure-production relationship indicates that the initial water drive was expansion,* that with the exhaustion of the expansibility of the edge-water body extending to the inferred faults of the Buena Vista syncline, the productive mechanism became that of gas expansion and, later, of gravity flow.

Another similar example is the Lakeview pool, which produces an extraordinarily permeable sand zone that buttresses on the north flank of the 35 Anticline. The great Lakeview gusher in 1910–1911, having produced more than 8,000,000 bbl. of oil,[9] may be said to have exhausted the pool of energy such as that from expansion of the reservoir's water, gas and oil as well as that from the expansion of the reservoir rock itself. Early in the 1930's the pool was rediscovered and rapidly developed as a pumping pool, gravity drainage being the significant production mechanism.

An example of effective cutoff and sealing, by faults of the tension pattern in the crest of an anticline, is found in the Standard Oil Company of California gas-storage reservoir, sec. 15, T.32 S., R.24 E., in the Buena Vista Hills. There a San Joaquin Clays-Pleistocene sand body is isolated by inferred faults. These faults are inferred from reservoir performance, for the area was developed prior to 1921. The inference is positive, however, for more recent drilling in sec. 14 and E. ½ sec. 15 has delineated the type tension-fault pattern with its displaced and sealed reservoir blocks. This reservoir has responded over a number of cycles of storage and withdrawal with practically identical pounds per square inch per 1000 cu. ft. stored and withdrawn pressure changes for each cycle. In other words, the reservoir is a tank—a closed system—and water drive is absent.

This discussion of Gulf Coast production is weakened, as is that of Kettleman North Dome, by the lack of sufficiently extended production data, or possibly simply by the writer's lack of knowledge of pools whose

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* A qualitative calculation might be helpful here. Using a factor for water expansion from the Critical Tables[28] of 2.5×10^{-8} cu. ft. per cu. ft. per lb. per sq. ft., and considering a tube of sand containing edge water, of uniform porosity 1 mile long and 1 sq. ft. in cross section, a decline in pressure of 2000 lb. per sq. in. will give 38 lin. ft. advance. Expansion is active throughout the entire body of edge water, and as the water-captured wells were drilled on the edge of the area of greatest development, of concentrated pressure decline, it is apparent that water expansion could, indeed, be the force that advanced the water in this pool.

performance could be cited. On the Gulf Coast, oil production extends beyond the crestal fault pattern in very few deep-seated structures. In most piercement and semipiercement domes, the flank reservoirs are bounded by radial and peripheral faults. That some faults can effectively cut off a sand is evidenced by the juxtaposition of productive and nonproductive segmental blocks around such domes as Pierce Junction. Also, differences in original reservoir pressure between adjoining blocks in fields of both the deep-seated and more advanced types have been noted. In a few deep-seated domes, such as Hastings and Conroe, oil accumulation extends beyond the central faulting into the flanks. At Clear Lake, in fact, the crestal, down-dropped blocks are nonproductive and the production is confined to the structural flanks. If these flank blocks are limited in size, it is from the effects of synclinal or regional faulting.

As to reservoir discontinuities effected by faulting, a generality that may apply is that where an entire sand body is faulted against a shale, migration may be cut off but where the movement has left sand against sand, there will be free, impeded or no[24] movement. In the outcrop, minor faults in sandstones generally show gouge and salt accumulations indicative of a bar to permeability. However, the relatively uniform water level across all blocks at Hastings indicates adjustment of pressure in geologic time. That such adjustment also occurs during the production of a field is likely under some conditions but may not always occur. Another difficulty is that the wells in many fields are now being produced to yield a uniform field-pressure pattern and differences in pressure between blocks are not allowed to develop.

CONCLUSION

Plainly, this paper is not a final one on the subject. However, the point that reservoir structure is important to the analysis of reservoir performance has been recalled and some of its ideas may contribute to the explanation of some performance anomalies, particularly as more structural facts and performance data are accumulated.

ACKNOWLEDGMENT

At the time that some of the thoughts here presented were first taking form, the writer had the encouragement of extended discussion with W. F. Barbat. Many others have since contributed to their development and the writer wishes to acknowledge especially the help of Paul Weaver and Stuart E. Buckley. Acknowledgment is also made to Mr. George L. Ratcliffe, General Manager, Baroid Sales Division, National Lead Co., for permission to publish this paper.

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DISCUSSION

(*H. C. Pyle presiding, Los Angeles Meeting*)

A. Gregersen,* Los Angeles, Calif.—Will the speaker define expansion water drive?

J. M. Bugbee (author's reply).—A definition would seem overly simple and I think a proper reply may be to mention the essential references, the papers by Schilthuis and Hurst[7] and Buckley.[8]

The concept is physically sound and of immense practical importance; for example, it is the belief of technologists that the entire East Texas field can be produced to exhaustion (some 5 billion barrels of oil) solely by the proper use of the expansion water drive.

M. L. Krueger,† Los Angeles, Calif.—I wonder if the formulation as to compressional-type structures has a very limited application; it may possibly be characteristic only of the west side of the San Joaquin. I cannot conceive of the radial faulting common to Rocky Mountain structures being explained by this formulation.

J. M. Bugbee.—Mr. Krueger may be right; certainly, one proposes application only after delineation justifies it. However, few Rocky Mountain fields have been exploited with benefit of the modern tools. Further, as I recall the mapping[25] of the cross faulting (Mr. Krueger's radial faults?) of the Salt Creek-Teapot structure, there is a sufficient similarity to the diagonal faulting in the Kettleman Hills to suggest a similar origin. The present formulation suggests that these failures resulted from beam stresses on the regional structure rather than from the conventional representation given by these authors in their Fig. 4 of the application of horizontal (tangential compression) and vertical (rising incompetent mass) forces. Also, the tension complex (the upper portion of the sawbuck) can be mapped at the surface in Salt Creek-Teapot (Thom and Spieker: *Idem*, 34) but its occurrence there is less impressive than that of the diagonal faulting; this is the reverse of the Kettleman condition. To be specific, in Kettleman North Dome displacements along the strike faults range from a few feet to about 300 ft. whereas in Teapot Dome vertical movement along the faults of this pattern seldom exceeds a foot or so. Displacements along the faults of the diagonal pattern in Kettleman are less than 100 ft. whereas in Teapot they range from a few inches to about 280 feet.

(*C. E. Reistle, Jr., presiding, Austin Meeting*)

Member.—How would the speaker explain the powerful water drive in a pool like Magnolia, Arkansas? This is a high-relief, domal structure and, in accordance with the present theory, should have synclinal faulting.

J. M. Bugbee.—I must plead a lack of knowledge of the area. Possibly, some one in the audience can answer the questioner?

W. A. Bruce,* Tulsa, Okla.—In a recent paper (p. 73, this volume), in which an analysis of the Magnolia pressure behavior was presented, a blanketlike formation was assumed for the Smackover lime. In the calculations for this pool the formation was assumed to extend infinitely in all directions. Subsequently, calculations were made for this pool in which it was assumed that the reservoir was closed off 12 miles from the pool. This later calculation showed that even this 12-mile limit would give enough water for the production of all the producible oil in the pool, provided reasonable control of the gas-oil and water-oil ratios was exercised. Furthermore, it was found that the pressure-production behavior of the pool to date could not be used to distinguish between the validity of the analysis that assumed an infinite porous zone and the analysis that assumed that the Smackover lime was closed to water migration at a distance of 12 miles from the Magnolia pool.

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* The Texas Company.

† Union Oil Company of California.

[25] W. T. Thom, Jr. and E. M. Spieker: Significance of Geologic Conditions in Naval Petroleum Reserve No. 3, Wyoming. U. S. Geol. Survey *Prof. Paper* 163 (1931).

* Carter Oil Co.

J. M. Bugbee.—Dr. Bruce has helpfully made specific the introductory point that with the prolongation of the life of oil pools under modern operation, the check of performance prediction against actual pressure-production-time data will often be much delayed.

D. Donoghue,* Fort Worth, Texas.—Regarding water drive, Mr. Bugbee makes the following statement: "The expansion concept was developed in studies of the East Texas field, and that field is a documented example of its importance." The mechanism of the water drive was not fully understood by engineers in the East Texas field until about 1934. Before that time, water drive was generally considered to consist simply of the flow of water into the reservoir from the surface outcrop of contiguous strata. Questions brought to light by the behavior of the East Texas field were somewhat embarrassing to this "artesian flow" idea.

At least two papers discussing the concept antedate the East Texas field, one by W. L. Russell[26] the other by O. E. Meinzer.[27]

J. M. Bugbee.—I believe this should be amplified, because my reading indicates that both authors specifically discarded (p. 150 of ref. 26 and p. 285 of ref. 27) the importance of the expansion of water for the concept of the compressible aquifer. T. V. Moore should be given the credit for first grasping the importance of water expansion (p. 174 of ref. 7). Further, the development of the concept with the East Texas data has happily been free of the confusion that would have resulted from consideration of the hazy, elastic reservoir concept (p. 166 of ref. 7 and the J. O. Lewis citation).

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* Consulting Engineer.

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An Electrical Device for Analyzing Oil-reservoir Behavior

By W. A. Bruce,* Junior Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

This paper covers the theory and present state of development of an apparatus for the nonmathematical analysis of complex problems of reservoir and well behavior.

At the present stage of development of this apparatus, it is capable of solving the water-drive problem of any reservoir performance for which a mathematical solution has been presented in the literature, either on the basis of steady or unsteady-state flow analysis.

The theory is presented for the extension of the scope of this analyzer along the lines of the present development. The resulting apparatus should be able to solve reservoir-performance problems previously thought too difficult for practical solution by mathematical means.

As an illustration of its operation and present scope, the analysis of a reservoir problem and synthesis of expected performance is presented.

Introduction

In this method† of analyzing problems of petroleum-reservoir and well behavior, the porous continuum of the reservoir is assumed to be divided into small blocks, or units. Each block is assumed to be small enough so that for a material balance on the fluids in the block an average pressure for the block can be used. In analyzing reservoir behavior from this point of view by mathematical means, a set of simultaneous difference equations would be obtained (two for each block), which must be solved or combined into a partial differential equation. In the method to be described here, instead of solving these sets of equations analytically, electrical units are constructed, which will behave in respect to the flow of electricity exactly as the reservoir units behave under various conditions of fluid flow. The electrical units are then wired together in the same way that the reservoir units are connected naturally by virtue of their geometrical locations and shapes.

Fluid-flow Equations

Consider a block in a reservoir. Assume that reservoir fluid (or fluids) is flowing in at one face and out at the opposite face, and that the block is small enough so that at all points the stream lines are within one degree of perpendicular to the face. Furthermore, assume that the pressure, p_1, at the upstream face (Fig. 1) is not more than one per cent greater than p_2 the pressure at the downstream face.

A material balance will show that the mass of fluid flowing out less the mass of fluid flowing in will equal the change in density times the fluid volume. This is expressed in the equation:

$$(Q_1 - Q_2) = V_o f \frac{d\gamma}{dt} \qquad [1]$$

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* Research Engineer, Carter Oil Co., Tulsa, Okla.

† This method of analysis was conceived after the author had made a detailed examination of apparatus designed and constructed by Dr. Victor Paschkis,[1,2] of Columbia University, for solving heat-flow problems. Dr. Paschkis brought to this country ideas on solution of unsteady-state heat-transfer problems by electrical means developed by C. L. Beuken[3,4] and himself. Lewis A. Pipes[5] recently has applied these same general principles to the solution of impact problems.

References are at the end of the paper.

Darcy's law gives the second equation:

$$\frac{Q}{\gamma} = \frac{k}{v} A \frac{\Delta p}{L} \qquad [2]$$

in which Q is the average mass rate of flow, which, by the assumptions above, may be either Q_1 or Q_2. L is the length of the block and A is the area of the face.

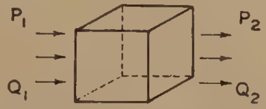

FIG. 1.—POROUS-MEDIUM UNIT.

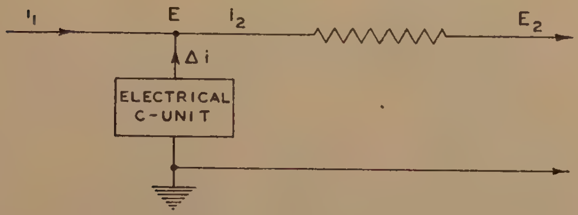

FIG. 2.—ELECTRICAL UNIT.

Suppose that γ is some function of pressure alone and q refers to volume rate. Then the fluid equations may be written:

$$q_1 - q_2 = \frac{V_o f}{\gamma} \frac{d\gamma}{dt} \qquad [3]$$

$$p_1 - p_2 = \frac{vL}{kA} q \qquad [4]$$

and these equations are true within the limit of the assumptions already made.

ELECTRICAL ANALOGY

Now consider an electrical circuit as shown in Fig. 2.

The electrical C-unit acts as a device for storage of electrical charge just as reservoir rock acts as storage for reservoir fluids. Hence, if current i_1 flows in and a greater current i_2 flows out of the unit, this difference in current must come from charge stored in the C-unit. If the unit is arranged so that for a net charge withdrawal there will be a corresponding reduction of potential, the qualitative analogy of this electric case to the fluid case is complete. In order that the analogy may be quantitatively exact and that current may be equivalent to fluid flow, and pressure equivalent to electrical potential, certain functional relations must be established.

The necessary relationship between voltage and current in the C-unit may be written

$$i_1 - i_2 = C_E F(E,t) \qquad [5]$$

in which $F(E,t)$ is some arbitrary function of voltage and time, depending upon the nature of the C-unit, and C_E is "capacitance," although not the commonly known dielectric capacitance.

In the general case, the C-unit must be made so that Eq. 5 is analytically equivalent to Eq. 3; hence, it must be that

$$C_E F(E,t) = \frac{V_o f}{\gamma(E)} \frac{d\gamma(E)}{dt} \qquad [6]$$

This expression makes Eqs. 3 and 5 alike except for variables.

The resistance to fluid flow is expressed by Eq. 4 as vL/kA. Similarly, the resistance to electrical flow is given by

$$R_E = (E_1 - E_2)/i \qquad [7]$$

in which i is average current. A comparison between Eqs. 4 and 7 shows that

$$R_E = vL/kA \qquad [8]$$

must be the value set for the electrical resistance.

Analyzer for Single-phase Compressible Liquid

The relation between density and pressure in a single-phase compressible liquid is

$$\gamma = \gamma_o e^{c(p-p_o)} \qquad [9]^*$$

in which c is compressibility. This becomes, when differentiated:

$$\frac{d\gamma}{dt} = c\gamma \frac{dp}{dt} \qquad [10]$$

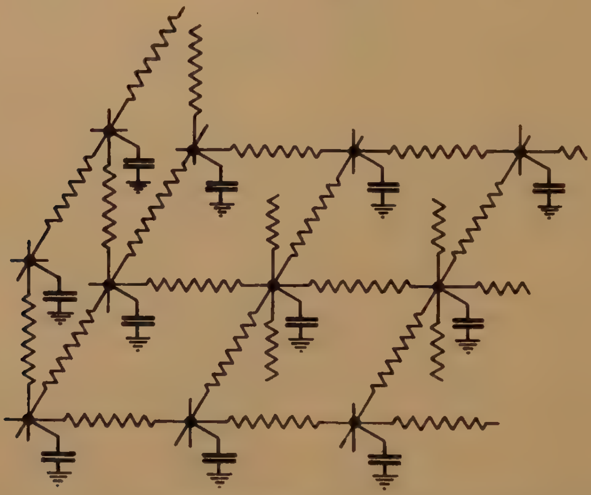

Fig. 3.—Part of three-dimensional electrical representation.

Combine this with Eq. 6, to give

$$i_1 - i_2 = fV_o c \frac{dE}{dt} \qquad [11]$$

This is the analytical definition of an electrical condenser whose capacitance C_E, is

$$C_E = fV_o c \qquad [12]$$

Hence, for this case the C-unit becomes a simple condenser because

$$i_1 - i_2 = C_E \frac{dE}{dt} \qquad [13]$$

is analogous to the relationship for the reservoir unit, which is

$$q_1 - q_2 = fV_o c \frac{dp}{dt} \qquad [14]$$

The fluid equations can be written for the three independent orthogonal coordinates and the result is six simultaneous equations for each block. Similarly, an electrical circuit can be constructed having six simultaneous equations necessary to represent its behavior. Since these equations are identical in form to the fluid equations, the behavior of the complete electrical circuit is analogous to the behavior of the entire fluid system. Fig. 3 indicates the network for representation for compressible liquid.

In the figure each focal point represents the center of a block at which it is assumed the expansion of the fluid is taking place. This focal center is the place to tie in the C-unit, which for compressible liquids is a condenser. The expanding fluid must get out of the block through the porous medium; hence every block is connected to every other block by a resistance.

The number of focal centers depends upon the accuracy desired and the variations observed because, as described above, each block must be small enough so that the assumption that p, an average pressure, can be used to replace p_{1x}, p_{1y}, p_{1z}, or p_{2x}, p_{2y}, p_{2z}, the pressures at the x, y, z faces of the block.

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* Applies over a wide pressure range for liquid phase, water, and oil and over a short range for two-phase oil and gas being released from solution.

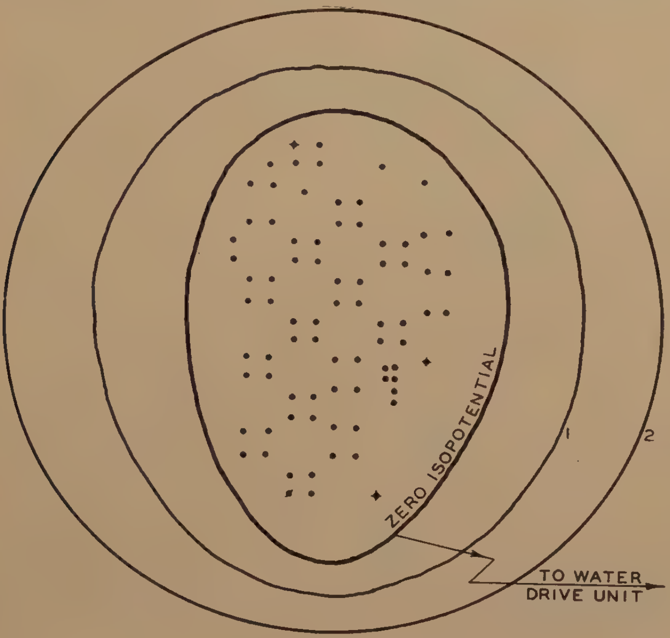

Fig. 4.—Pool unit.

Water-drive Unit

The water-drive treatment of a pool is strictly a problem of the flow of a compressible liquid, and if the formation is uniform in thickness a two-dimensional treatment may be considered, though this restriction is by no means necessary. Any geometrical complexity could be taken into account.

Suppose a field is as the one shown in Fig. 4. It is a simple matter, with an ordinary electric model, to show that isopotentials going away from the wells become nearly circles eventually, no matter what the well pattern may be.

A well pattern is set up in a low-conductivity electric model, and, on the assumption that at some distance the isopotentials become circles, a circular electrode is made to coincide with the isopotential as far from the wells as the size of the model will permit. Current is put into this outside electrode and taken out, the electrodes representing the wells in accordance with well-production rates. Then the area between the outside circle and the wells is explored, isopotentials are drawn in as shown and resistance between them is measured. The isopotentials are drawn close enough together so that the zone between two may be considered as a unit. The equations for fluid behavior in each unit are:

$$q_1 - q_2 = \frac{V_o f}{\gamma}\frac{d\gamma}{dt} \qquad [15]$$

and

$$p_1 - p_2 = R_F q \qquad [16]$$

in which R_F is the measured resistance to fluid flow.

Each unit may then be replaced by a

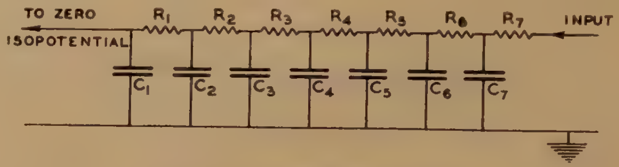

FIG. 5.—WATER-DRIVE UNITS.

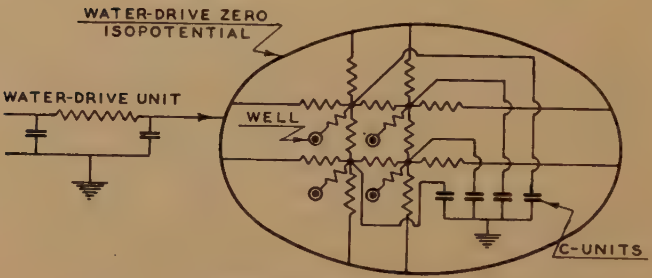

FIG. 6.—NETWORK REPRESENTATION OF A POOL.

condenser and resistor and the whole system can be connected as indicated in Fig. 5. The measurements with the electric model did not go beyond R_3; hence these additional values must be determined. It was noted that isopotential No. 2 was a circle. If the porous continuum is infinite in extent, isopotential No. 3 would be a circle and the resistance between No. 2 and No. 3 would be

$$R_F = \frac{v}{2\pi kb}\log_e\frac{r_4}{r_3} \qquad [17]$$

Furthermore, V_o of Eq. 15 would be

$$V_o = b\pi(r_4^2 - r_2^2) \qquad [18]$$

If the porous continuum is not large enough to be assumed infinite, it is simple to set up an electric model on a sufficiently large scale to take in the entire continuum. In such a model the pool would appear as a very small electrode, but once the isopotentials are found the scale can be changed.

The next problem is that of terminating the water drive. In the general case it must be carried far enough so that there is less change in potential in the last condenser than the limiting error. However, if the water drive ends in an outcrop that is known to be fed by water, this can be simulated by a battery of constant voltage. If the termination is a pinch-out or a fault, the units simply stop at the discontinuity, across which no fluid flow is supposed to take place.

OIL-ZONE UNIT

Two arrangements to handle the oil-zone problem will be discussed: (1) a network of resistors and C-units with a terminus at each well and (2) a sheet of conducting medium representing the permeable medium with distributed C-units simulating the expansive ability of the fluid.

In the first system a square array of wells would be represented as shown in Fig. 6, in which the distributed capacity of the fluid system to produce fluid is supposed to be associated with some circle at a distance from the well. The resistance from the focal center represents the resistance to flow of fluid into the well and is given by

$$R_F = \frac{v}{2\pi kb}\log_e\frac{r}{r_w} \qquad [19]$$

(r_w equals the well radius r a distance of 50 ft. or so from the well). This scheme would be reasonably simple to carry out for a very small pool drilled on a square pattern, but if irregular drilling were followed the complexities would make the problem tedious.

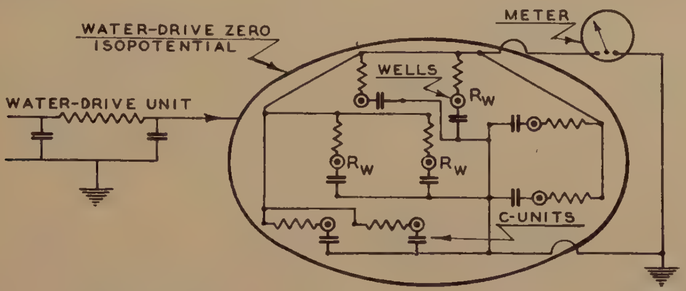

FIG. 7.—ELECTRICALLY CONDUCTING LIQUID REPRESENTATION OF A POOL.

A second scheme involves the combination of an electric model and the electrical C-units. The well pattern is laid out on a bakelite board over which is put a layer of slightly conducting water or glycerin. The wells are represented by large electrodes such that 80 or 90 per cent of the well potential drop would be observed between the radius of the actual well and the distance corresponding to this model representation of the well. The resistance to fluid flow from the radius represented by the model well to the actual well bore is taken care of by resistors as shown in Fig. 7.

Pressures can be corrected either to average pool pressure or flowing-well pressure.

APPLICATION TO GAS FLOW

Consider again a small block through which gas is flowing with the same general conditions and assumptions stated in connection with Fig. 1.

If the pressure drop is small and the mass rate of flow is Q_1,

$$Q_1 - Q_2 = fV_g \frac{d\gamma_g}{dt} \qquad [20]$$

in which density is the average density and the subscripts g refer to gas. Also,

$$p_2 - p_1 = \frac{Q}{\gamma_g} \frac{L}{A} \frac{v_g}{k_g} \qquad [21]$$

If the gas obeys the law $pV = zRT$,

$$\gamma_g = (\gamma_o/z)(p/p_o)$$

Hence,

$$\frac{d\gamma_g}{dt} = \frac{\gamma_o}{p_o z^2}\left(z\frac{dp}{dt} - p\frac{dz}{dp}\frac{dp}{dt}\right) \qquad [22]$$

Eq. 5 becomes

$$i_1 - i_2 = fV_o\left(\frac{1}{p} - \frac{1}{z}\frac{dz}{dp}\right)\frac{dp}{dt} \qquad [23]$$

or an electrical C-unit must be designed that will deliver current, $i_2 - i_1$, when there is a change in pressure or voltage, $-\frac{dE}{dt}$, and it must follow the rule shown in Eq. 23. Such an electrical device can be made with electronic tubes and associated equipment.

If $\frac{dz}{dp}$ may be considered to be constant (its variation at Magnolia, Ark., is expected to be 2 per cent in the next five years) the instrumentation becomes simpler and

$$i_1 - i_2 = i = \frac{fV_o}{E}\frac{dE}{dt} \qquad [24]$$

This becomes

$$\int_{t_1}^{t_2} Ei\,dt = fV_o(E_1 - E_2) \qquad [25]$$

The left side of this equation represents work or integrated power. Hence, a meter of the watt-hour type arranged to drive a linear scale potentiometer would represent the gas-cap unit.

These complexities can be taken care of in two other ways: (1) manual control and (2) addition of condensers at discrete intervals of time in accordance with Eq. 22 or 23.

GAS-CAP PROBLEM

The gas-cap problem, in which both gas and oil are factors to be considered, can be in a way similar to those in the treatment of single-phase gas and liquid. It is assumed that gravity will provide segregation and that for the time of the calculation the relative volumes of gas cap to oil zone will not change. This simplification can be removed by including differentials of volume in the equations and also the electrical C-units; or, from time to time, adding units to the entirely single-phase parts above and below the gas-oil interfaces.

CONVERSION FROM ELECTRICAL TO FLUID UNITS

The relationships between units are dictated by the pairs of analogy equations, 3 and 5, 4 and 7.

Thus, if it is assumed that the following numerical relationships will be used,

$$E/p = l \qquad [26]$$
$$C_E/C_F = m \qquad [27]$$
$$R_E/R_F = n \qquad [28]$$

it follows from Eqs. 3 and 5 that

$$q/i = n/l \qquad [29]$$

For the time factor, the form of the function $F(E,t)$ must be considered, because time is controlled by the interrelation of the two elements, resistance and capacitance.

In the case of compressible liquid, the equation for a condenser and resistor combine the two factors involved. Thus,

$$t_E/t_F = mn \qquad [30]$$

ANALYSIS OF PERFORMANCE AT DIX POOL*

The Dix pool, in Jefferson County, Illinois, was discovered in January 1938. It is on an anticlinal structure of the Bethel sand. The Bethel at this point is a smooth oval dome about 30 ft. thick. The oil zone has about 30-ft. closure. Laboratory analysis of cores shows 14 per cent porosity and 118 millidarcy permeability. Drilling has indicated that the Bethel extends, as a blanket sand with minor breaks, over a large area in southern Illinois.

The oil in the pool has a saturation pressure of 250 lb. per sq. in. and has been undersaturated during most of the pool's development. The wells are drilled on the 20-acre sunflower pattern, except on the southeast side, where some irregular development began during 1941. Wells have productivity indices ranging from 0.1 to 3.0, the average being 1.0.

In preparation of the analyzer for this problem it was divided into a pool unit and a water-drive unit. It was assumed that the major fluid in the pool unit was a compressible liquid of compressibility 6×10^{-6} (lb. per sq. in. units) and viscosity 2.5 centipoises, and that the fluid in the water-drive unit was a liquid of compressibility 3×10^{-6} and viscosity of 1.0 centipoise.

POOL UNIT, DIX POOL

The pool unit is indicated schematically in Fig. 4. Wells are represented by ⅛-in. diameter electrodes pressed into a 28 by 28-in. bakelite panel. Each well is located according to a scale map. The porous medium is represented by a 90 per cent glycerol and water solution, which has a resistivity of about 1.5 megohm-cm., and, since the Bethel sand at Dix is uniform in thickness, the depth of solution is uniformly about ⅜ inch.

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* For previous analysis of this problem by mathematical means see paper presented in February.[6]

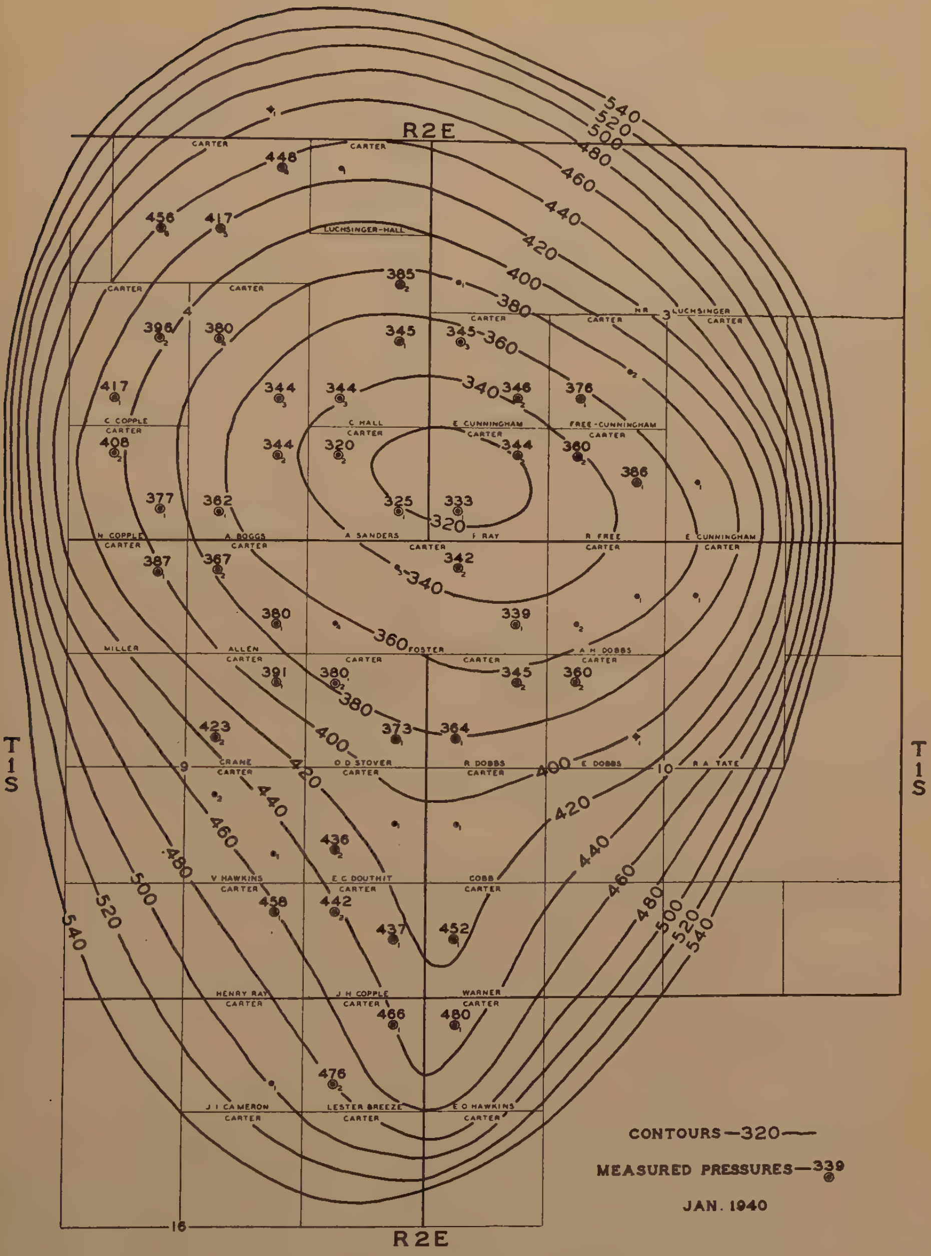


FIG. 8.—ELECTRICALLY DETERMINED PRESSURE CONTOURS, 1940.

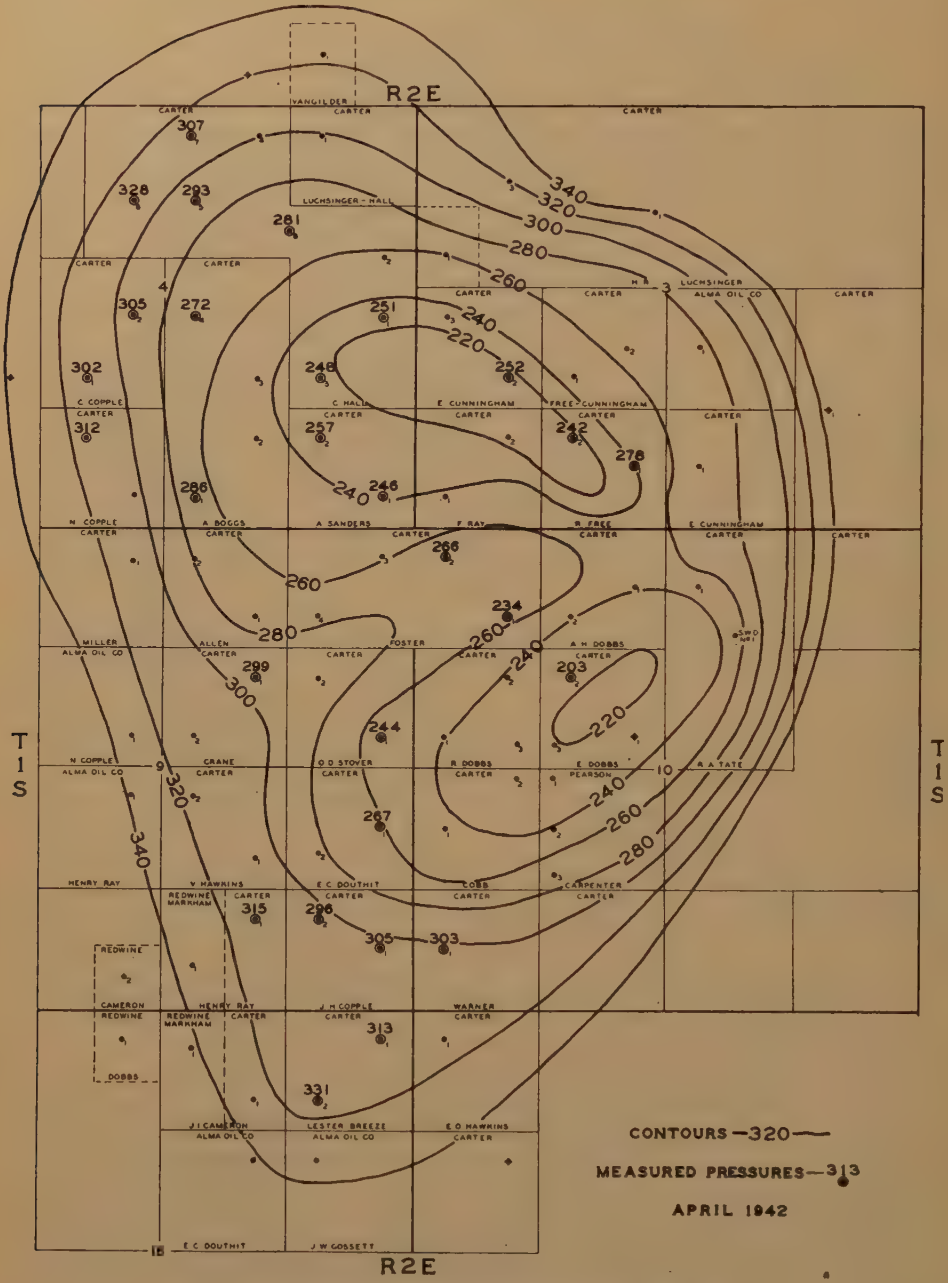


FIG. 9.—ELECTRICALLY DETERMINED PRESSURE CONTOURS, 1942.

For production, the 76 wells are grouped together into 20 subgroups. Capacitors are connected to each group in accordance with the area assigned to that group for drainage. Resistors are put in series with each group, according to the reciprocal of the summed productivity indices for the wells in the group.

The numerical relationships between pool and analyzer are:

$E/p = 1/10$
$C_E/C_F = 1/15$ (capacitance in microfarads)
$R_E/R_F = 2$ (resistance in megohms)

Thus, the time scale is:

1 second = 7.5 days
1 microampere = 20 bbl. per day

The location of the zero isopotential, indicated by Fig. 4, is accomplished by the following procedure: A potential is established between the wells and a circular outer metal ring indicated by the third ring in Fig. 4. Isopotentials are then plotted with a probe, and the one just enclosing all of the wells (called the zero isopotential in the drawing) is the new position of the metal strip and also the point at which the water drive is connected. The resistance between the zero isopotential and the next one is determined by the current-potential relationship in the glycerol, and this resistance is used to fix the resistance in one of the elements of the water-drive unit.

WATER-DRIVE UNIT, DIX POOL

A schematic drawing of this is shown in Fig. 5. Each element represents a certain part of the porous medium through which the water flows and in which the water expands as the pressure is reduced.

For the Dix pool these elements are taken as the porous medium between isopotentials, and each is arbitrarily chosen so that the resistance to fluid flow is $(v/2\pi kb)(0.405)$. For the first few sections the isopotentials are irregular contours but thereafter they are so nearly circles that the cylindrical formulas can be used and the ratio of successive radii becomes

$$r_n + l/r_n = 1.5$$

OPERATION AND RESULTS

In practice the production figures by wells are tabulated and grouped.

A timer starts calling time with 4 sec. equal one month and the well-group switches are closed in accordance with the average time at which each group of wells was drilled. Throughout this operation the variable resistors are adjusted to keep suitably placed microammeters showing the proper average daily production.

Vacuum-tube voltmeters are connected to the well electrodes of the pool unit and a record of their readings gives the pool pressure at the electrode.

To fix the values of resistances of the water drive and pool units, values were chosen from the permeability and viscosity data, as follows: For the water zone, $v/kb = 0.233$, and for the oil zone, $v/kb = 0.375$. The water-drive resistors were set at 34,000 ohms each and the glycerol was made up $\rho/b = 328{,}000$ ohms. This was on the basis of a uniform permeability of 118 millidarcys and the factors indicated above.

Data through December 1939 were put into the analyzer. The resulting pressures from the analyzer were about 15 per cent too low.

The water-drive unit and pool unit were adjusted until the resistances of the water-drive unit all were 30,100 ohms and those of the pool unit was 375,000 ohms. At this point the analyzer voltages seemed to agree best with observed pressures as far as the run was carried.

The synthesis of pressure data beyond December 1939 was continued and the results for each group were as close to the observed pressures as they had been in the analysis phase of the run. Once the resistances were set by the history of the pool up to 1940, no further changes were made to carry the synthesis into 2½ more years of development.

Representative results are shown in Figs. 8, 9 and 10. Fig. 8 shows the analyzer contours for Jan. 1, 1940. Pressures measured Dec. 26 to 30, 1939 are indicated at the wells. Similarly, contours for April 1942 are shown in Fig. 9. The pressures and analyzer data are shown in Fig. 10 for four representative individual groups and for the average of the 20 groups.

ACKNOWLEDGMENT

The author is indebted to B. M. Bradley, John Cooke, and Lois Cline for assistance in organization of data and operation of the analyzer and to the management of The Carter Oil Co. for permission to publish this paper.

NOMENCLATURE AND UNITS

Fluid

q_F = bbl. per day
p = pressure, lb. per sq. in.
r = distance, ft.
b = formation thickness, ft.
c = compressibility, bbl. per bbl. per lb. per sq. in.

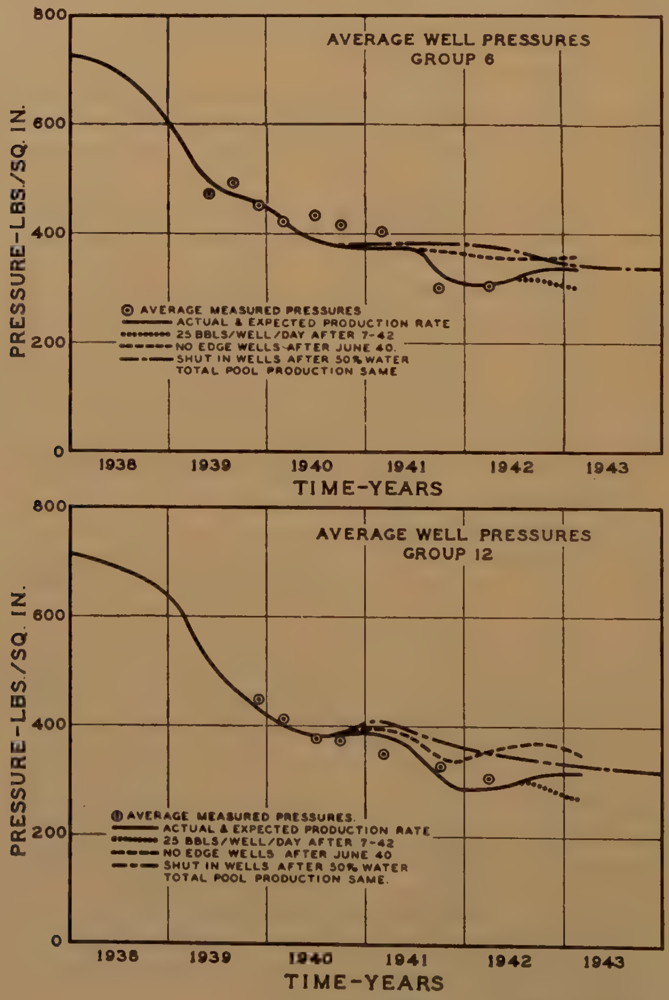
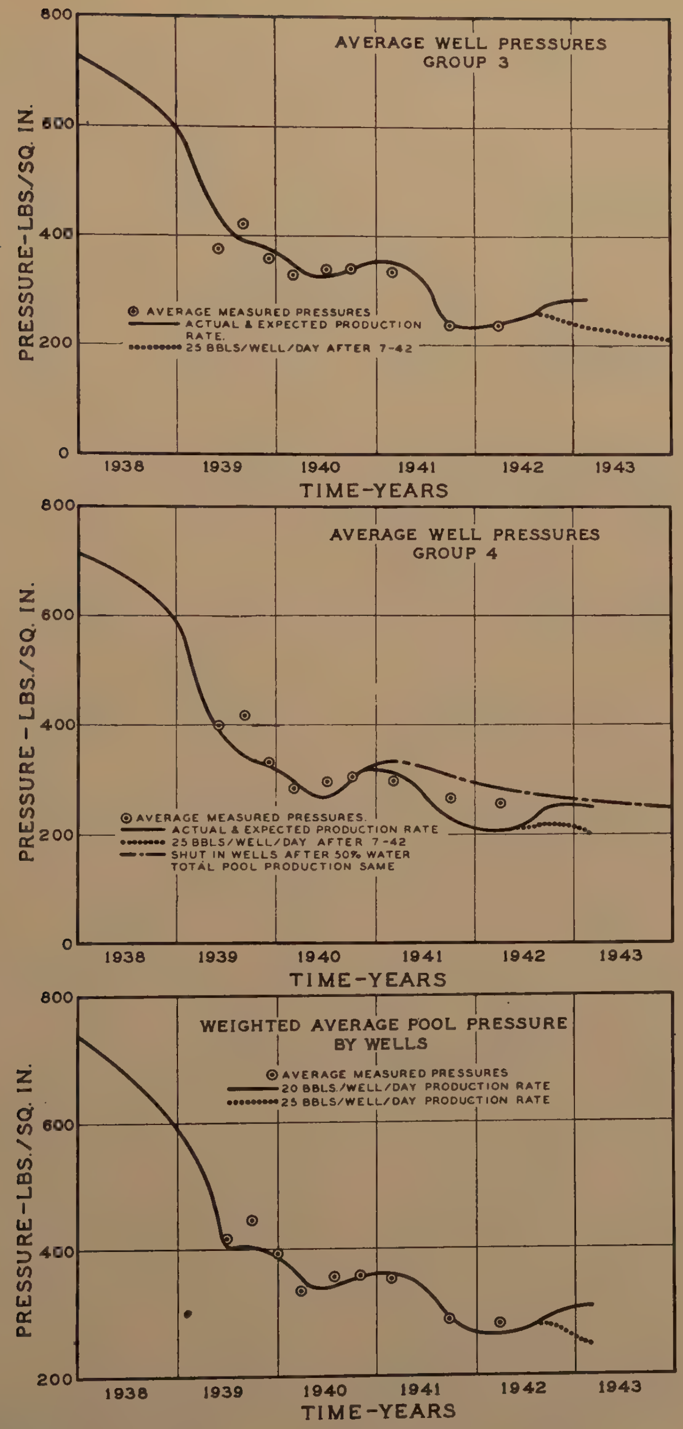


FIG. 10.—A COMPARISON OF ANALYZER AND



MEASURED PRESSURES FOR DIX POOL.

k = permeability in perms (1.127 darcys), bbl. per day per sq. ft. per lb. per sq. in. per ft.
v = viscosity, centipoises
V_o = total sand volume, bbl.
f = fractional porosity
γ = density
C_F = fluid capacitance $= \frac{V_o f}{\gamma}\frac{d\gamma}{dp}$ which for compressible liquids is $V_o fc$
R_F = v/k times-shape factor
t_F = time, days

Electrical

i = current, microamperes
E = potential, volts
r = distance, cm.
R_E = resistance, megohms
C_E = capacitance, microfarads
t_E = time, sec.

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DISCUSSION

(*C. E. Reistle, Jr. presiding*)

V. Paschkis,* New York, N. Y.—The accuracy of the method described in this paper depends to a considerable extent on the leakage of the electrical parts used in the analyzing equipment. One, although by no means the only, source of leakage is the (electric) condensers.

If the analyzer is built with special care, keeping the leakage very low, it becomes rather expensive. On the other hand, inexpensive material (especially condensers) and design lead to high leakage currents.

Obviously the second method was chosen by the author. It forces him to select the time scale rather large: 1 second = 7½ days. Five years are represented in the experiments by 240 sec., or 4 min. Within so short a time, it is hardly possible to adjust variable resistors to keep microammeters showing certain values. There is always a lag between observation of the microammeter and the readjustment of the resistor. This lag is constant and therefore is felt proportionally more in short experiments than in long runs.

In experiments with changing boundary conditions or changing internal properties, it is desirable to use better equipment with lower leakage currents, allowing the use of longer time for the experiments.

W. A. Bruce (author's reply).—Dr. Paschkis is quite correct in his observations that electrical leakage limits the accuracy of these experiments. It would be a great convenience if we had the same quality of electrical equipment for studying the problems of the petroleum reservoir that he has available in the heat-flow laboratory at Columbia University.

At the time this paper was written, an automatic control device was planned and this equipment has now been developed. It eliminates the necessity of setting microammeters by hand and permits higher accuracy with a shorter time scale. Thus, it appears that no experiment will have to be run for much longer than 5 min., whereas the electrical equipment now has leakage properties that would permit experiments of 10 min. duration.

These short-duration experiments were necessary originally because of electrical leakage. Now, with automatic control, they appear to be advantageous because of the reduction in time necessary for a complete analysis.

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Relationship between Velocity, Oil Saturation, and Flooding Efficiency

By R. C. Earlougher,* Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

Based on laboratory tests conducted with the use of fresh core samples as well as a considerable amount of field data obtained from numerous water floods in northeastern Oklahoma, it appears that for any given oil saturation there is a critical maximum velocity above which the oil-recovery efficiency falls off very rapidly. In effect, when a water flood is operated above this critical velocity, the injected water-oil ratio rises extremely fast, thus shortening the economic life of the flood and reducing the ultimate oil recovery. This critical velocity apparently varies considerably with the percentage of oil saturation of the sand, so that in effect the higher the oil saturation at the beginning of a flood the higher the velocity that can be used successfully. In reviewing several of the earlier floods in the Mid-Continent area, it is concluded that most of the failures were due to two things: (1) too low an oil saturation, such as 30 per cent, and (2) too high water-injection rates. Although considerably more field data are necessary to establish definite limits, it would seem that the proper field injection rate for a 330 by 330 or 440 by 440-ft. spacing varies from approximately 1 bbl. per foot of sand per day where the oil saturation is as low as 30 per cent up to 5 bbl per foot of sand per day when the oil saturation is as high as 45 to 50 per cent.

Introduction

With secondary recovery by water-flooding receiving more and more attention throughout the industry, a greater working knowledge of multiphase flow under field conditions becomes more and more necessary. A great deal of research has been carried on in highly idealized laboratory conditions, from which certain trends have been indicated, but with few exceptions no direct application to field use has been reported. Widely varying conclusions have been drawn from the mass of idealized laboratory experiments and often this divergence apparently was due to the neglect of connate or interstitial water.

Since interstitial water is such an important factor in water-flooding operations, it then follows that any laboratory flooding experiment must necessarily take it into account; and since it is difficult to set up laboratory models to allow for interstitial water, the next best procedure is to use fresh core samples for such tests. Even this procedure has its difficulties, inasmuch as it is possible to run only one flooding test on each sample, as each sample differs somewhat in character from all other samples. However, this disadvantage can be overcome to a large degree by the use of an extremely large number of samples.

The next question that arises is: "Is it possible to get uncontaminated core samples having a true oil and water saturation like that existing in the reservoir?" If the sand under consideration is still in the primary stage of production, with a normal or relatively high amount of gas still in solution in the oil, probably it is not possible to get a nonflushed core. On the other

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* Geologic Standards Co., Tulsa, Oklahoma.

hand, if the primary oil and natural gas of the sand under consideration have already been depleted, usually it is quite easy to get an uncontaminated core showing relatively true conditions of the oil and water saturation of the reservoir. This fact has been proved many times over for sands of the Mid-Continent having permeabilities ranging from 0 to 1000 millidarcys, and viscosities varying from 5 to 50 centipoises under reservoir conditions.

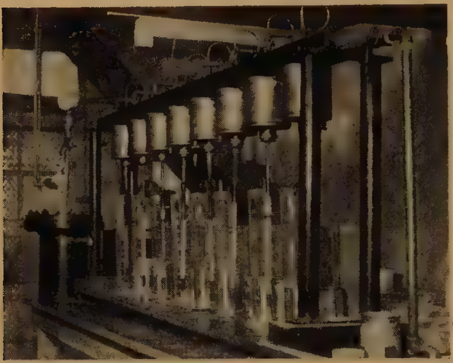

FIG. 1.—FLOOD POTS MOUNTED IN BATTERY.

LABORATORY PROCEDURE

During the past few years, hundreds of flooding tests using fresh core samples have been run by the author and his associates. Most of the core samples were about 2 in. in diameter and about 3 in. long. After a ½-in. hole has been drilled through the center of the core along the axis, the core is mounted in a flood pot in preparation for flooding. The pots are so constructed that flow occurs from the outside of the core to the center, the flooded oil and water dropping from the bottom of the pot into a graduated burette with siphon tube that has been filled with water. The recovered oil remains at the top of the burette while the water flowing through the sample siphons over into the graduated cylinder. A number of pots are mounted in a battery (Fig. 1) so that several samples can be flooded at one time. The flooding medium normally used is tap water supplied from a pressure reservoir (Fig. 2). Pressure is supplied by compressed air entering the tank through a pressure regulator.

FIG. 2.—PRESSURE RESERVOIR.

The core samples used for these flooding tests are taken in the field just as soon as the core is pulled. Each sample is sealed in a container at the well and then taken into the laboratory for flooding. These flood samples are taken as duplicates to the regular saturation samples. In this way it is possible to check the saturation values. After the flood sample has been completely flooded, the amount of oil recovered is calculated as barrels per acre foot. The core sample is then retorted and the residual oil content determined. This residual plus that recovered by flooding should equal the total oil in place in the sand. An easy check on this figure is possible as long as a duplicate saturation test has been run. It has been found that these two figures for total oil check more than 90 per cent of the time as long as the flooding tests are watched and regulated closely, so that no oil is carried through the siphon with the water. In cores where the two values do not check, the reason can usually be traced to a break in the uniformity of the sand.

Results of Laboratory Data

The primary purpose for the use of flooding tests as a routine core analysis procedure is to determine the amount of residual oil left in a sand after water-flooding, and then to estimate the amount of recoverable oil present in the sand.[1] However, it now becomes evident that such tests can be of far more value than for testing residual saturation or content alone. One of the most important results thus far indicated by these laboratory tests, is the mportance of velocity of water flowing through the sand and its relation to the oil-recovery efficiency and percentage of oil saturation at the time of the flood's inception. This factor of velocity is no stranger to the engineer in regard to its importance in the recovery of oil, especially by water drive, either natural or artificial. However, it has been kicked all about the field in so far as the degree or direction of its importance is concerned. Many engineers have long held that slower velocities of water encroachment through a sand will yield the greatest ultimate oil recovery,[2,3] while others still maintain that the highest possible velocities will yield by far the greatest oil recovery.[4,5] The data upon which this article is based very strongly support the theory that slower velocities are in most cases far more efficient than higher ones.

Field men in the Nowata district of northeastern Oklahoma learned early in their experience with water-flooding that it was necessary in many cases to restrict the water input of certain wells or else lose all or nearly all of their oil production from adjoining five spots. This, of course, was in direct contradiction to the early principle of the use of the highest pressure possible up to the limit of the overburden, together with the resulting injection rates. For a long time it was assumed by engineers that increased water production occurring as a result of high injection rates was no greater in proportion to oil produced than before with lower injection rates, but that because of larger volumes the field man merely "thought he was hurting oil production." With that idea the engineer laughed off the field man's opinion and went along his way still believing it possible to use just as great an intake rate as the individual wells would allow. It now becomes evident that the field man was correct—that there is a maximum injection rate or velocity, which definitely should not be exceeded if an efficient operation is to be carried on.

After data from the flooding of several hundred core samples had been assembled, curves of oil and water production vs. time were drawn up for many of them. The study of these curves soon revealed that, contrary to previous beliefs, the ultimate oil recovery was independent of the flooding pressure—samples were flooded at different pressures, varying from 5 to 50 lb. per sq. in. Some were flooded at a constant pressure; for others pressures were increased during the run. Further inspection of the curves indicated that the most efficient oil recovery was obtained from the samples that yielded a low rate of flow, no matter whether the flooding pressure was 5 or 50 lb. In other words, it became evident that the floodable oil was being produced from the samples at a definite rate and that if the flooding rate were increased the only effect was an increased flow of water through the sample with little or no increase in rate of oil production, which meant greatly increased water-oil ratios.

This fact was readily indicated by two sets of flood samples from one core. The

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[1] References are at the end of the paper.

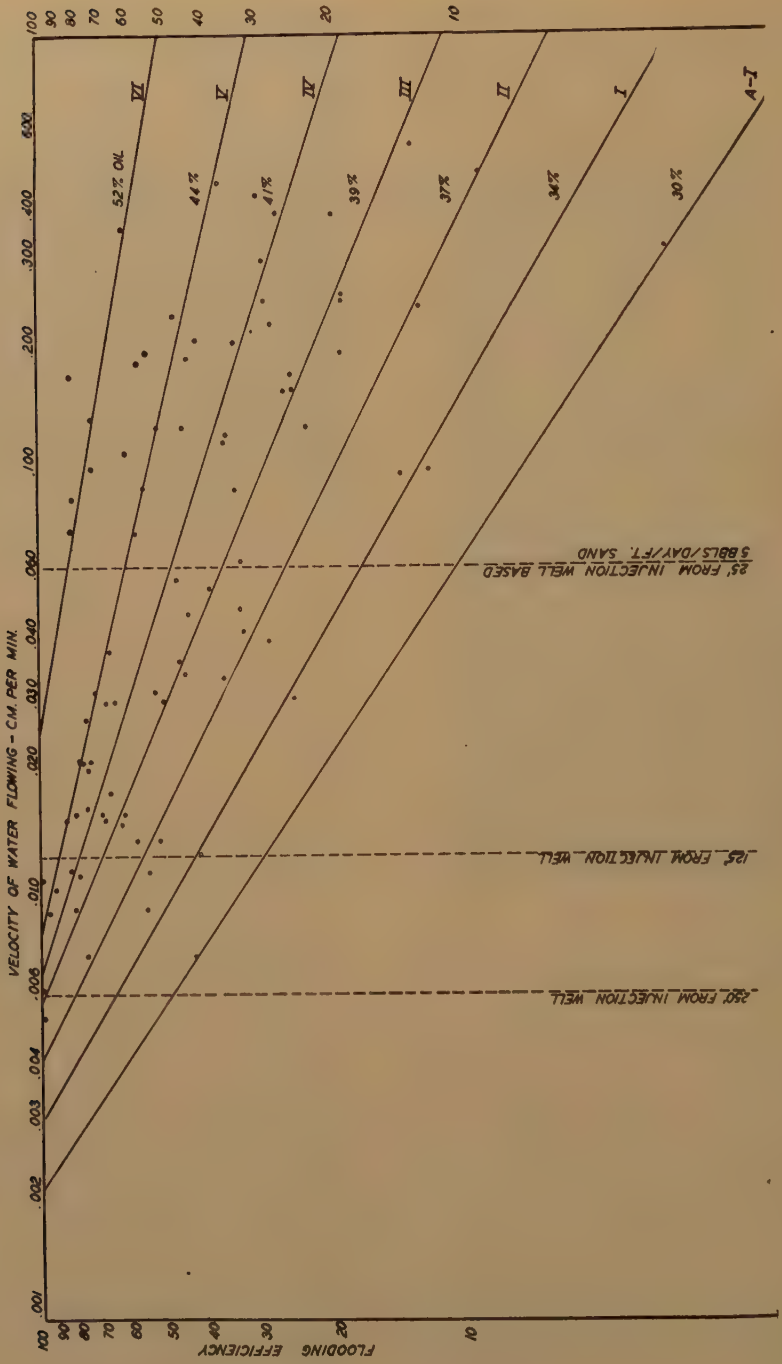

FIG. 3.—FLOODING EFFICIENCY VS. RATE OF WATER FLOWING.

TABLE 1.—*Summary of Flooding Tests*

Sample	Oil Recovery when Water in = 5000 Bbl. per Ft.		Pressure Used, Lb. per Sq. In.	Average Flooding Velocity, Cm. per Min.	Initial Conditions		
					Per Cent Saturation		Perm Md.
	Bbl. per Ft.	Flooding Efficiency (Ultimate)			Oil	Water	
1	115	98	5–50	0.011	38	57	20
2	160	80	5–50	0.011	30	63	20
3	140	56	5–10	0.087	42	51	130
4	80	47	5–10	0.053	38	36	160
5	300	79	5–10	0.020	41	38	54
6	30	32	5–10	0.042	29	36	70
7	110	53	25–50	0.024	43	43	14
8	30	25	25	0.148	39	48	19
9	65	26	25–50	0.147	31	32	94
10	115	34	25–50	0.191	34	35	150
11	250	66	25–50	0.027	39	42	14
12	100	27	25–35	0.383	46	33	100
13	10	25	25–50	0.028	33	46	5
14	50	50	25–50	0.028	42	62	6
15	90	42	25–50	0.194	32	33	30
16	95	47	25–50	0.212	35	36	20
17	325	74	25–50	0.126	57	28	40
18	75	29	25–50	0.238	58	28	17
19	250	76	25–50	0.019	48	41	8
20	245	86	25–50	0.015	41	34	13
21	225	58	25–50	0.067	40	32	15
22	180	100	25–50	0.003	37	45	3
23	105	34	25–50	0.086	44	33	20
24	300	77	25–50	0.025	41	44	2
25	180	69	25–50	0.028	40	32	6
26	150	75	25–50	0.020	43	33	20
27	170	71	5–20	0.015	24	49	7
28	310	80	5–20	0.032	49	33	100
29	190	42	5–50	0.012	64	30	84
30	230	62	5–20	0.349	46	37	50
31	50	28	5–50	0.038	15	50	60
32	255	59	5–50	0.013	45	24	15
33	340	77	5–50	0.016	45	35	16
34	210	68	5–50	0.017	44	33	60
35	45	19	5–10	0.237	50	33	100
36	90	56	10–50	0.009	31	39	20
37	15	43	10–50	0.008	27	63	8
38	145	45	10–50	0.032	41	27	71
39	60	55	10–50	0.011	39	61	40
40	235	98	10–50	0.005	43	38	1
41	315	99	10–50	0.006	43	27	8
42	350	95	10–50	0.009	47	23	10
43	140	52	10–50	0.013	45	25	30
44	135	44	20–50	0.044	43	32	32
45	165	70	20–50	0.015	36	31	20
46	80	28	20–50	0.211	35	41	90
47	160	64	20–50	0.014	38	30	40
48	85	82	20–50	0.009	40	39	10
49	50	33	20–50	0.045	42	23	4
50	240	84	20–50	0.011	36	35	20
51	295	68	20–40	0.036	47	34	1
52	45	39	20–40	0.051	18	62	25
53	75	45	20–40	0.120	34	66	80
54	400	83	20–40	0.083	55	22	70
55	355	83	20	0.159	46	35	17
56	330	82	10–50	0.015	42	39	20
57	10	3.3	10–50	0.313	36	39	80
58	10	12.5	10–40	0.235	27	42	76
59	5	9	10–20	0.478	20	55	130
60	250	77	10–50	0.007	39	31	25
61	270	83	10–50	0.007	38	32	45
62	165	46	10–50	0.032	37	25	60
63	100	36	10–50	0.031	35	59	40
64	30	14	10–50	0.094	31	52	70
65	35	12	10–50	0.096	27	51	52
66	120	92	20–50	0.010	31	39	10
67	150	63	20–50	0.015	43	30	30
68	110	29	20–50	0.299	37	35	90
69	145	36	20–50	0.112	40	48	66
70	140	44	50	0.175	43	30	15
71	280	62	50	0.106	32	39	36

TABLE 1.—(*Continued*)

Sample	Oil Recovery when Water in = 5000 Bbl. per Ft.		Pressure Used, Lb. per Sq. In.	Average Flooding Velocity, Cm. per Min.	Initial Conditions		
					Per Cent Saturation		Perm. Md.
	Bbl. per Ft.	Flooding Efficiency (Ultimate)			Oil	Water	
72	160	37	50	0.450	57	35	48
73	345	74	50	0.097	55	24	24
74	35	19	50	0.246	31	50	40
75	75	33	20–50	0.059	52	31	74
76	405	73	20–50	0.029	48	28	20
77	350	58	20–50	0.170	51	30	75
78	36	19	25–50	0.183	33	21	
79	120	30	25–50	0.416	35	25	
80	39	25	25–50	0.157	38	37	
81	60	23	25–50	0.119	50	38	
82	40	13	50	0.546	41	41	
83	310	52	50	0.122	49	25	
84	250	100	50	0.004	40	40	
85	200	55	50	0.181	59	20	
86	255	100	50	0.003	44	31	
87	315	100	50	0.004	53	30	

first set of eight samples was flooded overnight at a low pressure of 5 lb. per sq. in. At the end of 10 hr. the flooding pressure was increased but no more oil was produced. The second set of eight samples was started at 40 lb. per sq. in., the intention being to flood the samples out in a very short while. However, the final outcome was that it became necessary to let this second set run for a little more than 9 hr., or very nearly as long as the first set, before increase in oil production ceased to be noted. At the same time the total water input during the second run was many times higher, leading to a water-oil ratio far beyond that for the first set. Both sets of samples were then retorted, and it was found that the residual oil was virtually the same; likewise, the initial oil saturations of these samples were similar, so that the actual amounts of oil recovered were also similar for the two sets.

After this visual observation of the effect of rate of water flowing on the water-oil ratio, the flooding efficiency for each sample was calculated and then plotted against velocity of water flowing. In figuring the efficiency, an arbitrary ultimate limit for water was taken to be 5000 bbl. per acre-foot. Thus the amount of oil produced when the water input is equivalent to 5000 bbl. per acre-foot divided by ultimate total oil recovered represents the flooding efficiency. For example, if the oil production is 300 bbl. per acre-foot at the time the water through is equivalent to 5000 bbl. per acre-foot, and the ultimate oil production is 400 bbl. per acre-foot, the efficiency would be 75 per cent. The velocity of the water flowing is expressed as centimeters per minute and represents the average linear velocity. Fig. 3 shows the graphic results of such calculations plotted on log log paper. A summary of data used in the construction of Fig. 3 is given in Table 1. Listed are "amount of oil recovery at the time water throughput was equivalent to 5000 barrels per acre foot"; this recovery is expressed both as "Barrels per Acre-foot" and also as a "percentage of the total oil finally recovered with an unlimited amount of water." The latter figure is that used to express flooding efficiency. Also shown are "Flooding Pressures," "Average Flood Velocity as Centimeters per Minute," and "Initial Saturation Conditions of the Sample with percentage of oil, percentage of water and permeability." The latter values necessarily are based on results obtained from adjacent core samples. In Fig. 3, flooding efficiency expressed as a percentage is plotted against average flood velocity expressed as centimeters per minute. When the points were first plotted, it became apparent at once that in most cases the general trend was that the higher the velocity the less the efficiency; however, it was noted that the points were quite widespread. The data were reexamined to determine the cause of this variation. At first it was felt that permeability might be the governing factor. Finally it was discovered that the initial oil saturation seemed to be responsible for the variation, and then the relationship between oil saturation and flooding efficiency was determined, as indicated by the seven curves shown in Fig. 3.

The method used for establishing oil saturation values for the seven straight-line curves in Fig. 3 is as follows: Curves 1 and 6 were first constructed as the boundary limits of the data under consideration. Next, the four curves 2 through 5 were drawn in so as to obtain a division between curves 1 and 6. Finally Fig. 4 was used to establish values for the straight lines in curves in Fig. 3. In this figure, percentage of initial oil saturation was used as the abscissa, while curves 1 through 6 were used as the ordinate. Next, each individual test sample was assigned to the curve nearest it on Fig. 3 and its saturation value plotted in Figure 3-A against the curve number. For example, a point falling near curve 3 that had an initial oil saturation of 42 per cent was plotted in Fig. 4 opposite Ordinate 3 at a point equivalent to 42 per cent oil saturation. After all of the points had been so plotted in Fig. 4, the average saturation value for each curve number was calculated and shown as a triangle. It is to be noted from these average figures that the higher the initial saturation the higher the curve number. A smooth line was drawn through these average points and from this, saturation values were assigned to the six curves shown in Fig. 3. It is granted that there is considerable variation in the data as indicated in Fig. 4; however, when considering the fact that the initial saturation values are assigned from adjacent samples it is believed the variation is not out of line. It does seem quite evident that at least a general trend is established. The conclusion drawn from these data is that, for the most part, flooding efficiency is directly dependent upon the per cent oil saturation at the beginning of a flood and upon the velocity of the flooding water, and that there is a critical velocity depending upon the oil saturation. This critical velocity is defined as that velocity above which there is a rapid falling off in flooding efficiency. From Fig. 3, critical velocity for any given saturation is determined by the point at which any of the curves reach 100 per cent flood efficiency. In other words, using Curve 6 as an example which represents an initial oil saturation of 52 per cent the critical velocity is 0.022 cm. per minute. So long as velocity in the case represented by this curve is held below 0.022 cm. per minute, a flooding efficiency of 100 per cent should be obtained; however, if the velocity exceeds 0.022 cm. per min. an efficiency somewhat less than 100 per cent will result within the flood life, depending upon how much the velocity exceeds the critical point. When this critical velocity is exceeded, water by-

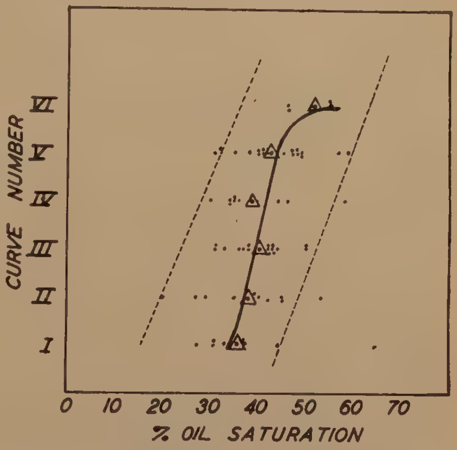

FIG. 4.—DISTRIBUTION OF OIL SATURATION.

passing sets in and results in the early abandonment of a flood because of the large quantities of water that have to be handled. This also results in a low flooding efficiency. The three vertical lines in Fig. 3 represent the velocity occurring in radial flow, 25 ft., 125 ft. and 250 ft. from an injection well when the intake rate is 5 bbl. per foot per day. From this it becomes evident that the effect of velocity upon flooding efficiency in the field is not to be neglected, since the range covered by curves in Fig. 3 is within the limits encountered in the field. This effect is not surprising in view of the data presented by Leverett and Lewis.[6] Buckley and Leverett[2] have also illustrated the detrimental effect of too high a production rate and the subsequent trapping of oil in sands of varying permeabilities.

Field Data

After the results described above were obtained, numerous field records were studied in an attempt to substantiate the laboratory findings. The results were most gratifying, as shown by the accompanying illustrations.

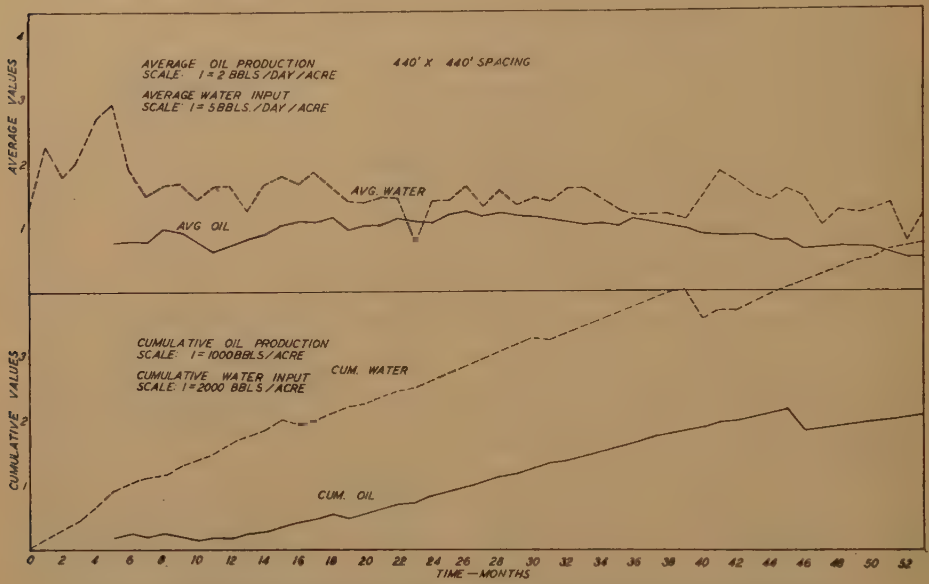

Fig. 5.—Water injection and oil production, 440 by 440-foot spacing.

Figs. 5, 6, 7 and 8 show water-injection and oil-production curves for four different leases. The thickness of clean sand in all cases is approximately 30 ft. net, and so the data are plotted on a basis of barrels per day per acre, thus making it possible to compare any one or all of the curves directly. Figs. 5 and 6 are of leases drilled on 440 by 440-ft. spacing, while Figs. 7 and 8 are for 330 by 330 and 330 by 377-ft. spacings. Also, Figs. 5, 6 and 7 represent sands having a relatively low oil saturation of approximately 32, 28, and 34 per cent at the beginning of the flood, while Fig. 8 represents a good saturation of about 40 per cent.

The injection rate used for the property in Fig. 5 averaged about 7½ bbl. per day per acre, or about 1 bbl. per foot of sand per day. At the same time, the oil produc-

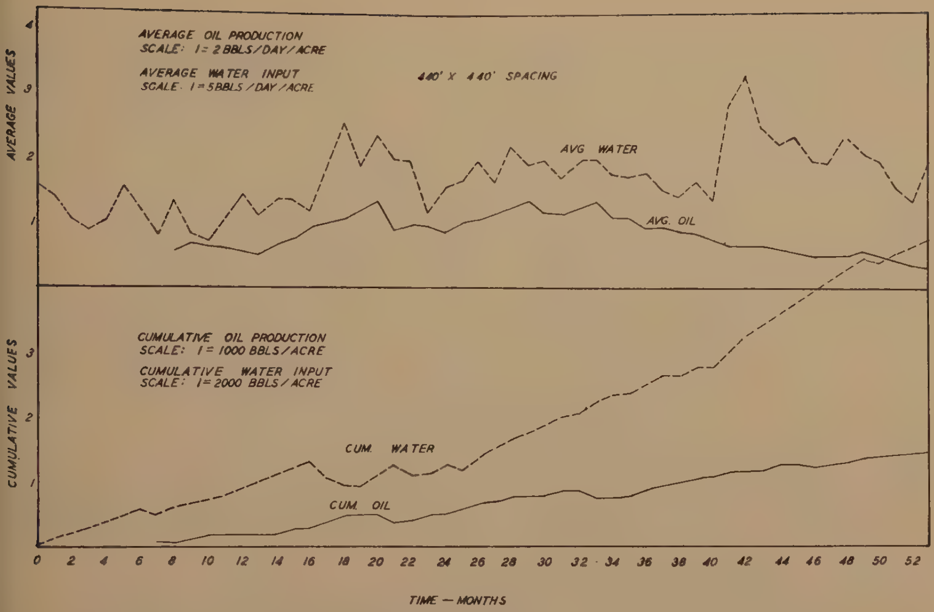

FIG. 6.—WATER INJECTION AND OIL PRODUCTION, 440 BY 440-FOOT SPACING.

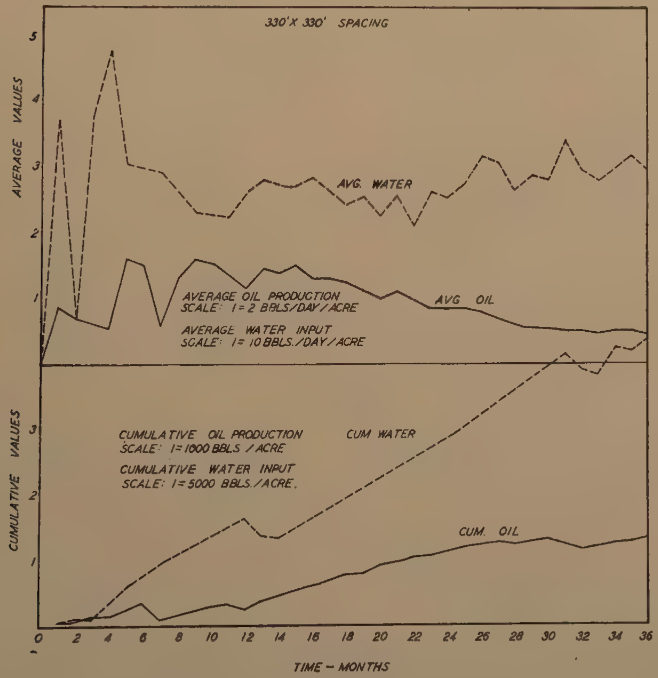

FIG. 7.—WATER INJECTION AND OIL PRODUCTION, 330 BY 330-FOOT SPACING.

tion came up to 2.4 bbl. per day per acre and remained at or above 2.0 bbl. per day per acre for two years. The water-oil ratio for the four years was 4.6 to 1, a good ratio for such a period.

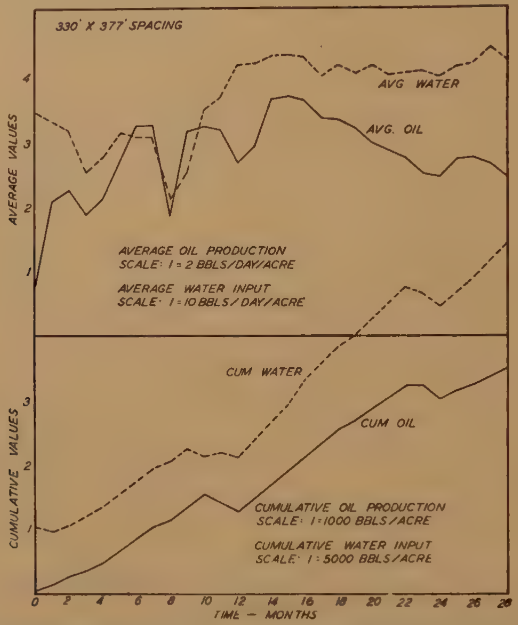

FIG. 8.—WATER INJECTION AND OIL PRODUCTION, 330 BY 377-FOOT SPACING.

The property represented by Fig. 6 also had an injection rate of about 7½ to 10 bbl. per day per acre, or 1.2 bbl. per foot per day. The oil production, like that in Fig. 5, came up to approximately 2.7 bbl. per day per acre and held at around 2 bbl. per day per acre for about 18 months. During the first three years the water-oil ratio was very favorable, but at the end of that time the operator boosted his injection rates. The results are quite evident. The cumulative water together with water-oil ratio rose very sharply with little or no increase in oil production. In other words, the increased rate of water flow did little or no good. The over-all water-oil ratio was 7.1 to 1.

Fig. 7, a property similar to 4 and 5 but developed on a 330 by 330-ft. spacing, shows the ill effects of too high an injection rate. This property was started off with relatively high pressures and injection rates. As shown by the curves, water was put in at a rate of about 25 bbl. per day per acre, or 2.2 bbl. per foot per day. It is true that the oil production peaked at about 3.2 bbl. per day per acre in a relatively short time; however, the production then fell off very rapidly, so that at the end of 2½ years it was just about even with that outlined in Fig. 5 in oil production and far behind in water-oil ratio. At the end of three years the water-oil ratio had risen to 17 to 1, which led to the early abandonment of the property and a low ultimate oil recovery.

Fig. 8, on the other hand, illustrates a sand with good oil saturation taking water at the rate of about 30 to 40 bbl. per day per acre, with very satisfactory results. A good oil-production rate of 6 to 7 bbl. per day per acre was obtained, and at the same time the water-oil ratio was held down to a very favorable level. In other words, the sand with a high initial oil saturation, as shown in Fig. 8, was adaptable to a much higher water-injection rate than were the sands of low oil saturation, represented by Figs. 5, 6 and 7.

Many other field reports substantiate the evidence presented here and bear out the fact that sands of low oil saturations, such as 30 to 35 per cent, must be flooded at necessarily slow rates if favorable recoveries are to be obtained. It now appears from both laboratory and field data that a water-injection rate of 1 to 2 bbl. per foot per day is about the maximum that should be used on a sand of such low saturation. On the other hand, if the saturation is between 40 and 50 per cent, injection rates as high as 5 bbl. per foot per day may be used without encountering serious water-oil ratios and low flooding efficiencies.

Conclusions

1. For any given oil saturation there is a critical maximum velocity above which the recovery efficiency falls off rapidly.

2. When this critical velocity is exceeded, the water-oil ratio rises extremely fast and thus shortens the economic life of the flood, and in turn reduces the ultimate oil recovery.

3. The critical velocity of a sand varies with the percentage of oil saturation, with sands of higher oil saturation having higher critical velocities. For example, at a given velocity the flooding action in a sand with 50 per cent oil saturation will be 100 per cent efficient, while for a sand with only 30 per cent oil saturation the flooding efficiency may be reduced to 25 per cent. These relationships observed in the laboratory have been verified by field data.

4. Recovery efficiency by flooding is largely dependent upon two factors; namely, percentage of oil saturation at the beginning of the flood and the velocity of the flooding water.

5. Several of the early flood failures in the Mid-Continent can be traced directly to oil saturations of only 30 per cent together with too high water-injection rates. In cases where low injection rates, for instance 1 to 1.5 bbl. per foot of sand per day, have been used much better results have been obtained. While it is mechanically possible to reduce a 30 per cent oil saturation to 20 per cent, it is not normally economically feasible because of the extremely high water-oil ratio resulting from water channeling through the sand and a low flooding efficiency. On the other hand, because of the higher efficiency occurring when flooding a sand of 40 per cent saturation, it is practically possible to reduce such a saturation to a lower residual by water-flooding, because of the lower resultant water-oil ratio. In other words, it is easier in the field to reduce a 40 per cent oil saturation to 20 per cent than it is to reduce a 30 per cent oil saturation to 20 per cent.

6. It appears that the proper field injection rate for a 330 by 330 or 440 by 440-ft. spacing lies somewhere between 1 bbl. per foot of sand per day for a low oil saturation such as 30 per cent, and 5 bbl. per foot of sand per day for a high saturation such as 45 to 50 per cent.

7. More field data are needed in order to determine a closer working relationship between water-injection rates, percentage of oil saturation, and flooding efficiency.

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DISCUSSION

(P. E. Fitzgerald presiding)

H. S. MILAM,* Chelsea, Okla.—We all know that various rates of water injection are being used, but it is general practice to use the highest pressure possible up to the limit of the overburden, to make the tight wells take as much water as possible and restrict the flow into the wells that take the water more freely, in an effort to keep the well volumes equalized as nearly as possible—until some producer starts making too much water, when some near-by injection well is throttled.

Now that sufficient field data have been obtained to be compared with results in the laboratory, we find another use for the analysis of the core, and another reason why more cores should be taken.

The thoroughness with which this paper covers the subject leaves no room for argument, and the only thing that I might add would be that the viscosity of the oil should also be taken into consideration. If the paper deals with oil of average viscosity, it would seem that an oil of higher gravity might be moved faster with the same efficiency, and an oil of lower gravity would have to be moved more slowly to obtain the same efficiency of recovery.

When the conclusions drawn from this paper are put into practice, more oil should be recovered from sections of sand with less saturation. As an economic factor, this practice will operate just as would an increase in the price of crude oil, and permit more of the properties to be flooded, leading to additional conservation by increasing the reserves, increasing the recovery, and permitting a longer life for the producing property.

K. B. NOWELS,† Abilene, Texas.—Mr. Earlougher's paper brings out clearly the relationship between velocity, oil saturation and the efficiency to be secured in water-flood operations. The information and data presented undoubtedly will have a wide application in secondary-recovery operations in which water-flooding is used, and it is to be regretted that we do not have more correlative investigations that can tie in directly observations made in the laboratory with those observed in the field.

The important fact brought out by Mr. Earlougher is that recovery efficiency by flooding is largely dependent upon two factors—percentage of oil saturation at the beginning of a flood and the velocity of the flooding water. His observation that for any given oil saturation there is a critical maximum velocity above which the recovery efficiency falls off rapidly is logically confirmed by facts, both in the laboratory and field observations; also, that when this critical velocity is exceeded, the water-oil ratio rises extremely fast, reducing the economic life and ultimate recovery of oil.

The practical application of Mr. Earlougher's findings seems to indicate that for normal flood spacing the proper injection rate lies between 1 bbl. per foot of sand per day for a low oil saturation such as 30 per cent, and 5 bbl. per foot of sand per day for high saturations such as 45 to 50 per cent. Even without laboratory or field evidence to confirm this relationship, it is a logical one.

Desirable as it is, however, to secure the maximum efficiency possible from water-flooding operations, it is frequently necessary to compromise and use a higher rate of intake than might be thought possible in order not to prolong the life of a flood beyond normal economic expectancy. The reviewer is familiar with several sand bodies now under water-flood development, where a so-called low oil saturation (expressed in percentage of total pore space) still represents from 450 to 800 bbl. per acre-foot, which is a satisfactory "pay load" in anyone's secondary project. In these formations there are also fairly large percentages of interstitial water. These conditions exist because of the high porosities prevailing, as well as high permeabilities that lead to the production of connate water with the oil from the very first. Under these circumstances, output wells may be permitted to flow their production and the handling of water is no particular problem.

Properties of this type, ordinarily considered from the standpoint of Mr. Earlougher's findings, would call for an injection rate of possibly 1 bbl. per foot of sand, yet for all practical purposes higher injection rates can be used, because extra amounts of water produced do not necessarily have to be pumped, even though the water-oil ratio is higher than might be considered efficient. In other words, possibly the sands of high permeability with good oil content, and yet having high percentages of interstitial water, may be compared with the group of samples in the second series of flood-pot tests Mr. Earlougher describes, in which a high rate of water injection was used, with a resultant high water-oil ratio, even though the time consumed and the amount of oil recovered was about the same as for the tests employing a lower rate of injection. Although more water is handled with the oil, perhaps this fact presents no problem when the wells are flowed.

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† Consulting Petroleum and Water-flood Engineer.

I do not hold any brief in favor of high injection rates for normal sands, but I do believe that it may not be so essential to watch efficiency where output wells are permitted to flow; or where high interstitial water percentages would seem to call for slow injection rates, even though the oil saturation in terms of per acre-foot is high—particularly where high permeabilities exist.

The question arises as to what type of results could be secured in the flood-pot tests if it were possible to use an oil-wet sand in the efficiency tests. It would be very interesting if Mr. Earlougher could make the tests on this type of sand and at the same time correlate the findings with flood performances in the field from oil-wet sands.

In the discussion of Mr. Schilthius' paper on Connate Water in Oil and Gas Sands,[7] W. S. Walls presents data that seem to indicate that for sands of similar physical characteristics better recovery of oil is secured and the residual oil saturation after flooding is less for water-wet sands (and most sands are of this type) containing high connate-water saturation. Perhaps this also points to the fact, as I mentioned above, that with relatively large amounts of connate or interstitial water in the pay sand, normal and satisfactory recovery of oil may be secured in a satisfactory time even in spite of high injection rates.

For sands such as the Bartlesville or its equivalent in the northern Oklahoma and southern Kansas water-flood areas, there is no doubt that the best practice calls for close control of injection rates and flood efficiency. Mr. Earlougher's paper deals with this type of property and the data presented are of sufficient value to constitute a noteworthy contribution to the technology of water-flooding.

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[7] *Trans.* A.I.M.E. (1938) **127**, 212.

Gravitational Drainage of Liquids from Unconsolidated Wilcox Sand

By Roscoe F. Stahl,* W. A. Martin† and R. L. Huntington,‡ Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

A marked gravitational segregation of liquid has been observed to take place in a number of volumetric fields toward the later stages of their oil-producing periods. This phenomenon has been pronounced in thick, highly permeable sand formations such as those of the Wilcox zone in Oklahoma City. This observation has prompted considerable research directed toward the semiquantitative determination of the equilibrium saturation distribution of oil vertically throughout a formation at final depletion. In this paper, data are also presented showing the transient distribution of liquid at different stages of the depletion period. Other experimental results show the effect of temperature on the drainage rates of water, Wilcox crude oil, and a close-cut heptane fraction. Intermittent drainage of liquid produced saturation gradients that might well be expected from the flow theories involved. Yields of the various liquids varied from 50 to 75 per cent of the original fluid content of the sand-packed (4 in. by 8 ft.) vertical tube.

Introduction

In certain volumetric oil fields the performance of the reservoir during the latter part of its producing life is governed to a large extent by the downward movement of liquid due to the force of gravity. This is especially true of formations having thick or tilting beds of uniformly high permeability, free of shale breaks. Leverett[4] and Katz[3] have presented original data and discussed the theory relating to the capillary and gravitational forces acting on liquids contained in a sand body. These investigators have pointed out the importance of such studies in the estimation of future reserves as well as the original fluid content of a reservoir.

In this previous work, no data have been reported showing the history of saturation distributions during the drainage period. Since a knowledge of these transients is helpful in obtaining crude oil from such a reservoir, the authors have obtained these data during this investigation.

Experimental Apparatus

The drainage tests were carried out in two vertical tubes, 8 ft. high and consisting of 2-in. and 4-in. standard wrought-iron pipe, respectively. Each tube was equipped with a water jacket, which could be kept virtually isothermal (± 1.0°F.). A diagrammatic sketch of the 4-in. tube and its auxiliaries is shown in Fig. 1.

At 6 in. above the base of the tube, and at every foot above this point, core nipples were inserted through the water jacket. These nipples were closely fitted with steel-plug inserts during each drainage run. At the end of the run, these inserts were removed so that cores could be obtained from the sand-packed tube.

This paper is an abstract of a master's thesis in Chemical Engineering presented to the University of Oklahoma by Roscoe F. Stahl. He was assisted by W. A. Martin, who received the B. S. degree in Chemical Engineering. Manuscript received at the office of the Institute Sept. 23, 1942. Issued in Petroleum Technology, January 1943.

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[4] References are at the end of the paper.

The bottom of the tube was fitted with a short ¾-in. nipple, into which was inserted a ¼-in. nipple perforated by many very small holes. A 100-mesh copper screen was soldered into position covering the perforations, in order to prevent loss of fine sand from the tube.

Auxiliary equipment consisted of condensers for both top and bottom of the tube, and a pressure chamber for filling the sand-packed tube. The pressure chamber was equipped with a calibrated glass tube for determination of the amount of liquid that flowed into the tube.

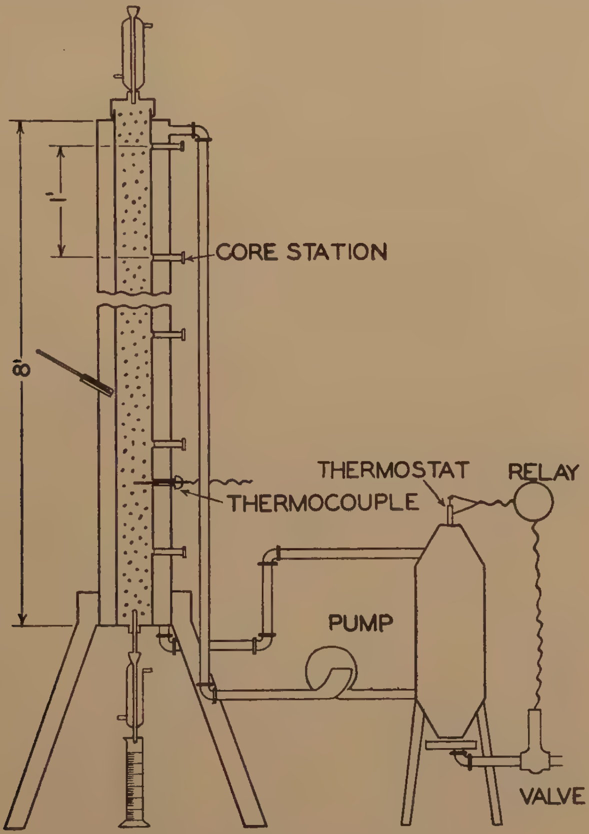


Fig. 1.—Diagrammatic sketch of apparatus.

Porosity

The tube was packed with a Wilcox sand from an outcrop near Ada, Okla., by tamping and vibrating the tube with blows of a hammer. This sand is from the same geologic formation as the Wilcox sand of the Oklahoma City oil field. It is unconsolidated and consists of well-rounded grains of quartz. A sieve analysis (Table 1) was made on oven-dried sand (free water and water of crystallization totaled 0.15 per cent by weight, based on dry sand).

Table 1.—*Sieve Analysis*

Sieve Size, Mesh	Weight Per Cent Retained
50	2.45
70	14.65
100	31.50
150	36.80
200	12.14
Pan	2.46
	100.00

The average diameter of this sand has been reported to be 0.0055 in.[2] after the methods of Fancher and Lewis.[1]

The absolute porosity of the reservoir was calculated to be 31.9 per cent. All subsequent packings provided substantially the same porosity.

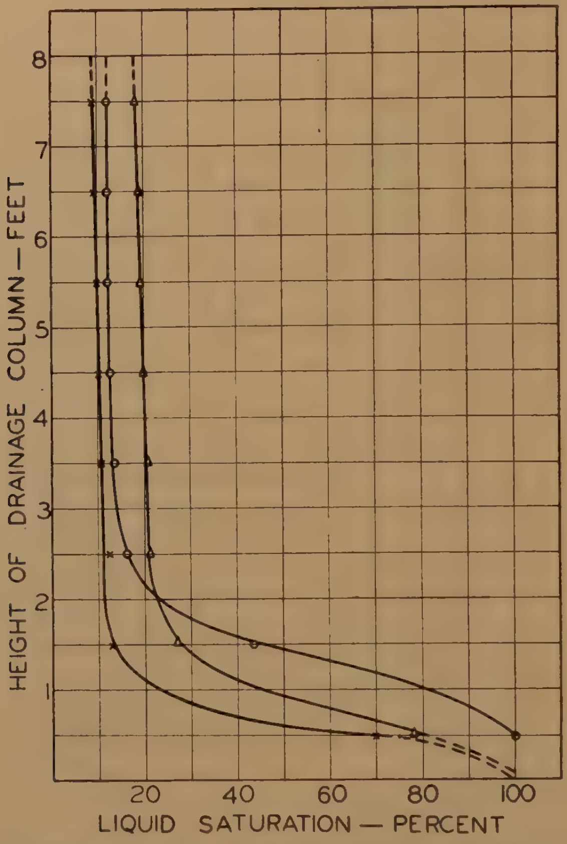


Fig. 2.—Saturation distribution for equilibrium.

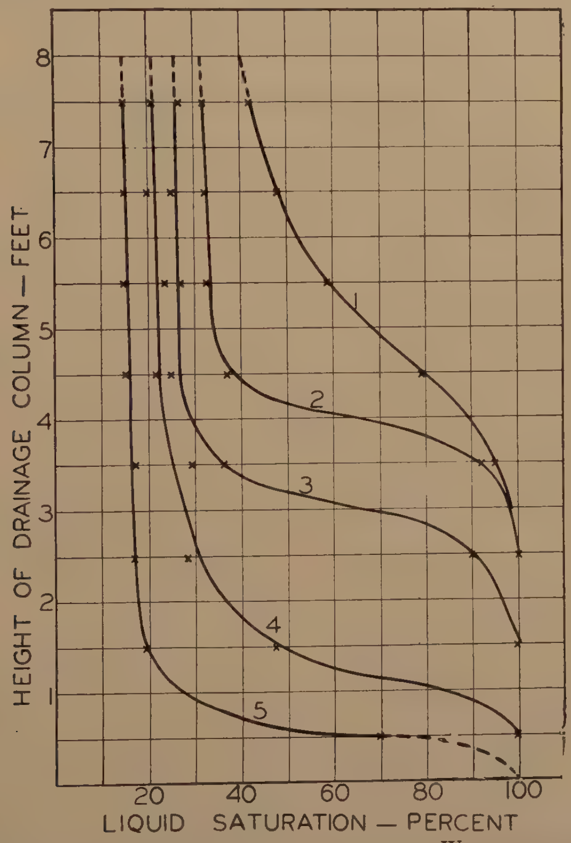
Fluid	Symbol	Temperature, Deg. F.	Drainage Production, Percentage of Original Amount in Place	Time
				Hr. Min.
Normal Heptane	×	64	73.0	
Water	o	100	52.2	11 30
Wilcox Crude Oil	Δ	100	65.3	69 30

Permeability

Dry natural gas was used in the determination of the permeability of the sand in the packed tube. An average of 7.5 darcys was obtained as a result of six tests.

Filling Tube with Liquid

The sand-packed tube was filled with liquid, which was forced in through the base of the tube. Liquid was allowed to flow out of the top of the tube in an amount equal to or more than the volume required to fill the pore space. The tube was then allowed to drain for several hours and filled again in like manner, an accurate record being kept of the net amount received by the tube. After this second filling, the tube was ready for the drainage runs. This second filling seemed to be necessary in order to assure consistent results when check runs were made.



[FIG. 3.—TRANSIENT SATURATION DISTRIBUTION CURVES FOR WILCOX CRUDE OIL AT 130°F.

Curve	Drainage Production, Percentage of Original Oil in Place	Time	
		Hr.	Min.
1	8.2	0	35
2	16.4	1	36
3	32.8	3	51
4	49.2	8	0
5	72.5	56	0

PRODUCTION AND RATE OF DRAINAGE DATA

To collect these data, it was necessary only to open the cock at the bottom of the tube and record the collection of fluid in a graduated cylinder at regular time intervals, extending from the time of starting to several days or weeks.

SATURATION DATA

At completion of drainage, or when cores were wanted, the plugs in the core stations were pulled and samples taken by means of a cork borer. The cores were immediately placed in test tubes and corked tightly. Saturation was determined by firing weighted amounts of the sample. All saturation data are presented in percentage by volume of reservoir fluid per unit volume of pore space.

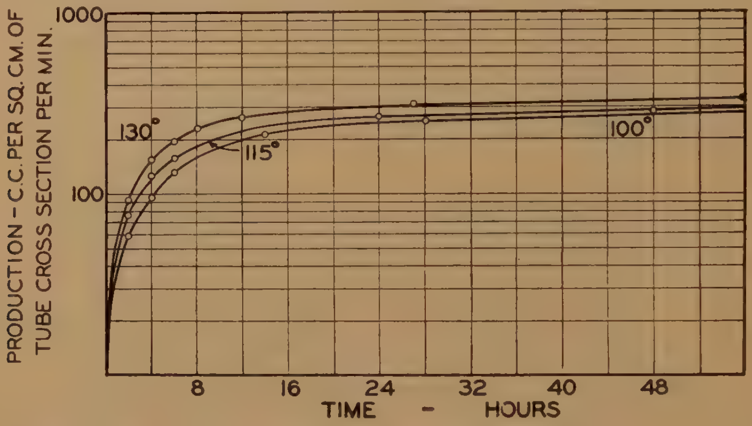


FIG. 4.—ACCUMULATIVE DRAINAGE CURVES FOR WILCOX CRUDE AT 100°, 115° AND 130°F., RESPECTIVELY.

PHYSICAL PROPERTIES OF FLUIDS

The A.P.I. gravity of the fluids was taken by hydrometers checked against a Westphal balance.

The viscosity of the fluids was determined by use of a modified Ostwald viscosimeter that had been standardized by the United States Bureau of Standards.

The surface-tension measurements were made on a du Nouy tensiometer.

Hempel distillations were according to the A.S.T.M. designation D285-41.

These properties are shown in Table 2.

DISCUSSION OF RESULTS

A comparison of the equilibrium drainage curves for water, Wilcox crude oil and a heptane fraction has been made in Fig. 2. The curves have the same general shape as those reported by Katz and by Leverett.

History of Transient Distributions

The depletion of a reservoir by gravitational drainage involves the unsteady flow of liquid downward. To picture such a flow process graphically calls for the securing of transient distributions of liquid at several times during the producing life of the field. These data were obtained by stopping each run when the tube was partly drained and by quickly removing core samples before any appreciable changes could take place in the tube itself.

TABLE 2.—*Physical Properties of Fluids*

Properties	Water	Heptane	Wilcox Crude Oil
Gravity, deg. A.P.I. at 60°F. .	10.0	63.2	38.2
Kinematic viscosity, centistokes:			
At 64°F.	1.060	0.680	
80°F.		0.624	
100°F.	0.680	0.566	5.81
115°F.			4.85
130°F.	0.510		4.30
Surface tension, dynes per cm.:			
At 64°F.	73.0	24.0	
84°F.	61.0	22.9	27.5
100°F.	60.0	22.4	27.3
115°F.			26.2
130°F.	58.1		25.5
Hempel distillation, deg. F., 250-ml. samples:			
Ml. over initial boiling point		168	
Ml. over end point		206	

The cavities caused by taking these cores were refilled with fresh sand before the tube was refilled with liquid. In taking these cores, the sampling was done by starting at the top of the column, in order to avoid any disturbance of the sand that might take place if the first samples were taken at the base of the tube.

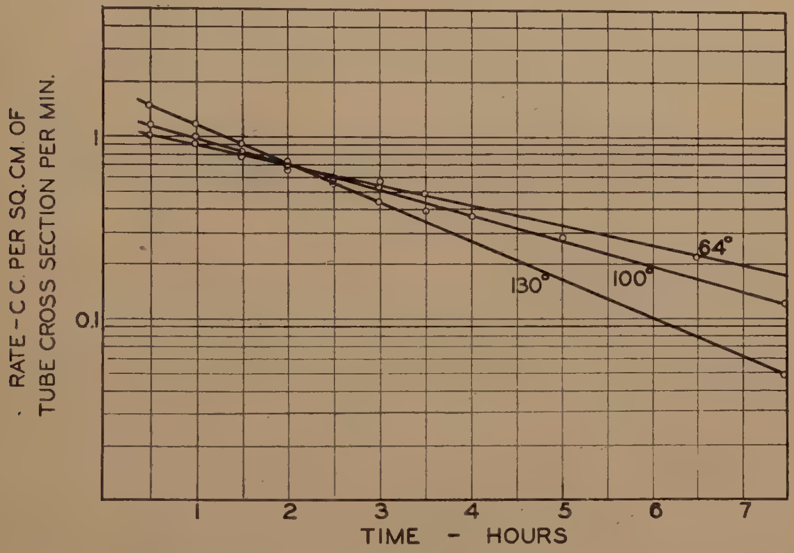


FIG. 5.—DRAINAGE RATES FOR WATER AT 64°, 100° AND 130°F., RESPECTIVELY.

Five such transients for Wilcox crude oil drained at 130°F. (the original temperature of the Oklahoma City Wilcox reservoir) are shown in Fig. 3. As might be expected, the depletion is most rapid in the uppermost part of the tube, where no influx of crude oil replaces the part of the liquid that has drained out. It is interesting that the depletion rate, though rapid at first at the top of the tube, flattens off toward the later stages of drainage.

Material balances on these runs checked fairly well (± 5.0 per cent) for the final equilibrium saturations. The errors were greater for transients taken at partial drainage, since the core borer evidently forced some of the crude oil away from the sampler as it penetrated the highly saturated sand.

Effect of Temperature on Drainage

Wilcox crude was drained down to equilibrium saturation (no further drainage) at 100°F. The rate was proportional to the temperature in the early stages but toward the end of the producing life the rate at 130°F. fell below that of 100°F. or 115°F. This statement means that the rate at the higher temperature was higher than for the lower temperature when the same amount of oil was present. The slower drainage rate at the higher temperature should be compared with that of the lower-temperature runs during the same lapse of time. The higher temperature did produce a slightly greater total recovery of crude oil (Fig. 4).

The same relationship between temperature and drainage rate held true for three runs made on water at 64°F., 100°F. and 130°F., respectively (Fig. 5).

Intermittent Drainage

An experimental run was made in order to determine the transition that would take place in a reservoir where an initial production period was followed by a shutdown and later on by another producing period. After Wilcox crude oil at 130°F. had been drained from the tube for 3½ hr., it

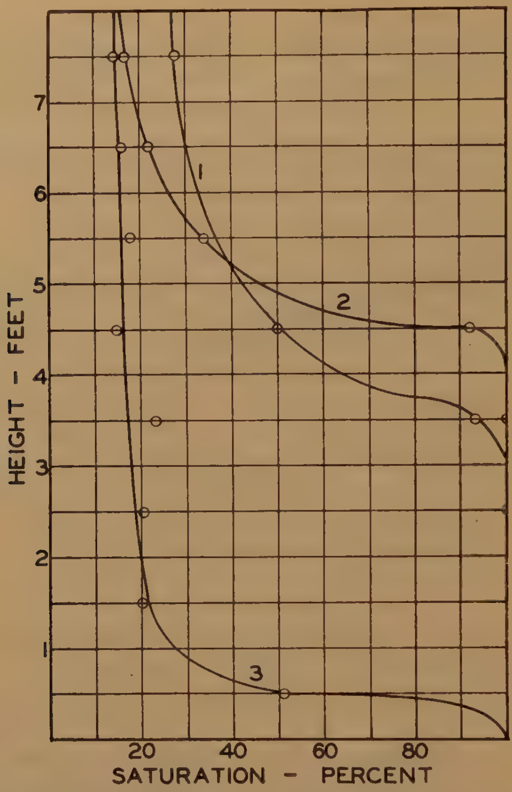


FIG. 6.—INTERMITTENT DRAINAGE OF WILCOX CRUDE OIL AT 130°F.
Curve 1, saturation distribution at 3½ hr. of drainage.
Curve 2, saturation distribution tube shut in 18½ hr. after 3½ hr. of drainage.
Curve 3, equilibrium or complete drainage after total time of 25 hours.

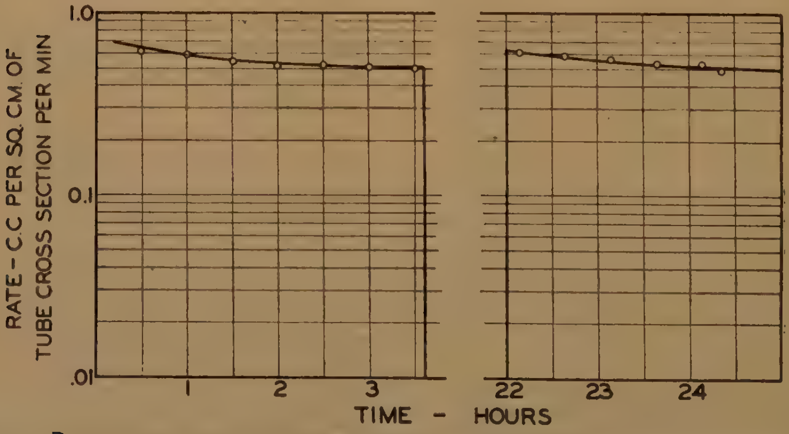


FIG. 7.—RATE OF DRAINAGE OF WILCOX CRUDE OIL AT 130°F. WITH INTERMITTENT FLOW.

was shut in for 18½ hr. Cores were taken at the beginning of the shutdown period and also at the close. The distribution of saturations at the time the tube was shut in is represented by curve 1 of Fig. 6. At the end of the shutdown period the gradient had changed to that represented by curve 2. During the 18½-hr. period, drainage had continued within the sand body, the upper end of the tube having been depleted almost to equilibrium depletion while the central part of the tube had become richer from the accumulation.

The rate of production history for this intermittent run is pictured in Fig. 7. The drainage rate was considerably faster just after the shutdown than it was just before the tube was closed in. The same amount of oil was present in the sand body during the shutdown but the effectiveness of the permeability had been enhanced by the build-up of the height of oil having 100 per cent saturation within the sand pores.

The rate of drainage from the 2-in. vertical tube checked closely (± 5 per cent) with the rate from the 4-in. tube, based on the cross-sectional areas of the two tubes.

CONCLUSIONS

The original experimental data presented in this paper substantiate the results of Leverett and Katz, and add to our knowledge of the performance of certain types of oil reservoirs. Much work remains to be done on the study of gravitational drainage before mathematical equations can be developed that will make possible the prediction of the transition of fluid saturation distributions during the history of the producing life of a reservoir.

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DISCUSSION

(*Donald L. Katz presiding*)

E. BRUNNER,* Emeryville, Calif.—In the conclusion it is stated: "Much work remains to be done on the study of gravitational drainage before mathematical equations can be developed that will make possible the prediction of the transition of fluid saturation distributions during the history of the producing life of a reservoir."

One cannot take exception to this statement as such; but standing as a conclusion of the present paper it might be taken by some to imply that a great many experiments of this type should be made before any mathematical development is attempted; and with this one may disagree. I think such work as described in this paper is useful and should be done, but that its full value can only be realized if it is accompanied by theoretical developments. Such experiments differ so greatly from field conditions that one can hardly hope to apply the results *directly* to field problems. In order to solve the field problems it is necessary to develop a theory that will allow the behavior of the field to be calculated in terms of laboratory measurements on the actual field rocks and fluids.

The value of such experiments as this is to serve as a test of the theory and as an indication of the direction in which the theory requires modification. Thus one should make a theory and attempt to calculate with it the results of such experiments as this, even though the theory may be obviously inadequate to deal with the highly complicated practical problems in which one is really interested. If one succeeds, the theory may be applied to somewhat more complicated situations and perhaps even to the simpler practical problems, with some confidence. If one fails, the nature of the failure will suggest the kind of modification that must be made in the theory and the type of new experiments that must be made to test it. It is by such close interaction of theory and experiment that a body of knowledge can arise that will make possible the solution of the practical engineering problems, which alone have importance in themselves.

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To demand either that the development of theory or the acquisition of experimental data be postponed until the other phase of research is completed is to cripple the process by which practical knowledge is obtained. Without theory, one will not know what to do with the experimental data; without experimental data, one cannot know whether the theory is valid nor how to modify it in order to make it more nearly so.

The point of contention, if indeed there is one, is the relative efficacy of the purely inductive method and the intimate combination of induction with deduction, which has been responsible for most of the advances in modern science.

R. L. Huntington (author's reply).—The authors agree with Dr. Brunner that the development of theory should not be allowed to lag too far behind any experimental program. Recognition of the value of theoretical attack is given to previous investigators.

The depletion history of a reservoir by drainage involves the unsteady flow of fluids through porous media, the decline curves being somewhat similar to the depletion of many reservoirs which have produced under unrestricted flow. To the knowledge of the authors no satisfactory theory has been advanced to date which will enable an engineer to predict the future producing rates of an oil field; however, no one can dare say that the inductive method has not been successful, although from a "purely" scientific viewpoint such methods might be termed "Edisonian."

Surface Energy Relationships in Petroleum Reservoirs

By H. K. Livingston*

(Austin Meeting, October 1942)

Abstract

A technique has been developed which makes it possible to determine the spreading pressure of liquids and solids, for simple systems. Data for surface tensions, interfacial tensions, spreading pressures, and contact angles for water, heptane, and silica are tabulated. These results can be applied to the evaluation of capillary rise and displacement pressure in a petroleum reservoir. Appropriate equations are presented and the application of these equations is discussed. The presence of surface-active components affects both capillary rise and displacement pressure and also seems to influence the rate of fluid flow.

Introduction

The purpose of this paper is to supplement and bring up to date the last article on the subject of the surface chemistry of petroleum reservoirs, that of Garrison in the 1935 *Oil and Gas Journal*.[1] A discussion of the "adhesion tension" concept used by Garrison has been presented in another publication,[2] together with the reasons for the recommendation that the term "adhesion tension" be abandoned. In view of the fact that some of the data used by Garrison have been superseded by more recent work, it seemed advisable to call attention to this fact and present the more important data currently believed to be correct.

In the earlier paper, Garrison set up the equations that relate solid-oil and solid-water interfacial tensions to each other, and applied data from Bartell and Miller[3] to these equations. However the adhesion tension measurements made by Bartell and Miller involved a confusion of symbols, so that they did not actually measure the spreading pressure, $\gamma_S - \gamma_{SF}$.[2] The spreading pressure is a convenient method of indicating the amount by which the surface energy of a solid surface is lowered on immersion in a liquid or vapor. Since the initial value of the free surface energy is represented by the symbol γ_S and the final value is γ_{SF}, the spreading pressure is $\gamma_S - \gamma_{SF}$. A technique has now been developed[4] that makes possible the determination of $\gamma_S - \gamma_{SF}$ for simple systems. This method would be very difficult to carry out with a multicomponent system such as exists in the petroleum reservoir. However, already results have been obtained for $\gamma_S - \gamma_{SF}$ for water and heptane in contact with silica and graphite. These values will be of the same order of magnitude as those in the petroleum reservoir. Accordingly, it is possible for the first time to discuss the surface-energy relations of the petroleum reservoir on a semiquantitative basis.

Preliminary Generalizations

A petroleum reservoir may contain the following four phases: gas, hydrocarbon liquid, aqueous liquid, and solid. The three fluid phases are dispersed through the solid reservoir rock. If gravity were the only force acting, it is obvious that the

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[1] References are at the end of paper.

gas phase would occupy the uppermost portion of the reservoir, with the oil below it and the water in the lowest position. However, because the fluids are merely saturating a porous solid, the relationships are more complex. The various surface energy relations that exist in the reservoir will affect the distribution of the fluids with respect to depth, the proportions of gas, oil, and water produced, and the relative amounts of gas, oil, and water recovered from the reservoir.

The following thermodynamic quantities must be considered:

1. The surface tension between oil and gas.
2. The surface tension between water and gas.
3. The interfacial tension between water and oil.
4. The spreading pressure (change in free surface energy) at the reservoir rock-gas interface.
5. The spreading pressure at the reservoir rock-oil interface.
6. The spreading pressure at the reservoir rock-water interface.
7. The contact angle between gas, oil, and rock.
8. The contact angle between oil, water, and rock.
9. The contact angle between gas, water, and rock.

The distribution of the fluids in the reservoir can be obtained from the equation for capillary rise:

$$\left(\frac{1}{R_1} + \frac{1}{R_2}\right) \gamma_{F_1F_2} \cos \theta_{SF_1F_2} = \Delta \rho h g \quad [1]^*$$

where R_1 and R_2 are the radii of curvature of the interface between the fluids, $\theta_{SF_1F_2}$ is the contact angle between the two fluids and the solid, $\gamma_{F_1F_2}$ is the interfacial tension between the fluids, $\Delta\rho$ is the difference between the densities of the fluids, h is the height reached by the denser fluid above the noncapillary level and g the gravitational constant.

The level to which a liquid rises in a petroleum reservoir depends upon the hydrostatic pressure and the capillary rise. The denser fluid will rise above the noncapillary level to a certain extent, as given by Eq. 1. The values of R_1 and R_2 will depend on the dimensions and packing of the reservoir rock. In a general way, $\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$ will vary inversely as the grain size of an unconsolidated sand. So it can be said that the extent to which capillary forces raise oil above the noncapillary gas-oil interface increases with the surface tension and decreases with the grain size and the contact angle. Similarly, the penetration of water into an oil sand will be greater, the greater the interfacial tension and the smaller the contact angle and the grain size. The gas-oil and oil-water ratios obtained during the early stages of production will depend, of course, to a large extent on the distribution of oil, gas, and water in that zone of the reservoir.

The foregoing discussion applies to the reservoir in the natural condition and relates to the equilibrium condition existing therein. After the reservoir has been penetrated, the displacement pressure is of more importance than the capillary rise. This is given by an equation analogous to Eq. 1:

$$\Delta p = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) \gamma_{F_1F_2} \cos \theta_{SF_1F_2} \quad [2]$$

where Δp is the displacement pressure.

If F_1 is gas and F_2 is oil,

$$\begin{aligned} \gamma_{SF_1} - \gamma_{SF_2} &= \gamma_{F_1F_2} \cos \theta_{SF_1F_2} \\ &= (\gamma_S - \gamma_{SF_2}) - (\gamma_S - \gamma_{SF_1}) \quad [3] \end{aligned}$$

It must be emphasized that Eq. 3 cannot be applied to oil, *water*, and solid, unless the proper qualifications are made. For oil and gas, the same components exist in both phases, but Eq. 3 will not be valid for an oil-water-solid system unless the oil is saturated with water and the aqueous phase is saturated with the hydrocarbon components.

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* This mathematical treatment is the same as that used by Leverett.[5] The symbols that have been employed (γ, θ, and ρ) are used in the same sense as in Leverett's paper, though it has been necessary to make use of the subscripts S, F_1, F_2, and F_3, to designate solid and fluid phases.

A discussion of the application of these equations will be given following the presentation of pertinent numerical data.

MAGNITUDE OF ENERGY RELATIONS

The thermodynamic quantities that are of interest in connection with surface relationships in petroleum reservoirs have been listed in the preceding section. For most of these quantities it is now possible to give values either for idealized systems that approximate natural reservoir conditions or for certain natural systems that have been studied. For the idealized systems, chemically pure heptane, water, and silica will be used as the equivalents of petroleum, connate water, and reservoir rock. Surface and interfacial tensions and contact angles were determined by the usual methods. The spreading pressures on solids were obtained by determining adsorption isotherms for crystalline powders of known area and integrating the Gibbs adsorption equation[6] to evaluate $\gamma_S - \gamma_{SF}$. The data are given in Table 1.

TABLE 1.—*Surface Energy Relations for Petroleum Reservoirs*

Thermodynamic Function	Symbol	Value for Natural System (at Reservoir Temperature and Pressure), Dynes per Cm.	Reference	Value for Idealized System (at Room Temperature and Atmospheric Pressure)	Reference
Surface tension between oil and gas (or surface tension of heptane)	γ_{F1F2}	16 to 23	7,8	20 dynes per cm.	9
Interfacial tension between water and oil (or heptane)	γ_{F2F3}	30 to 36	10	51 dynes per cm.	11
Spreading pressure at rock-gas (silica-heptane vapor) interface	$(\gamma_S - \gamma_{SF1})$			39 ergs per sq. cm.	4
Spreading pressure at rock-oil (silica-liquid heptane) interface	$(\gamma_S - \gamma_{SF2})$			59 ergs per sq. cm.	4
Spreading pressure at rock-water (silica-water) interface	$(\gamma_S - \gamma_{SF3})$			315 ergs per sq. cm.	2,4
Contact angle[a] between gas, oil, and rock (heptane-silica)	θ_{SF1F2}			0°	12 13
Contact angle[a] between oil, water, and rock	θ_{SF2F3}			52° to 135°	See discussion

[a] Contact angles measured in the denser fluid.

Table 1 shows that the spreading pressure of water on silica is much greater than the spreading pressure of the hydrocarbon, and this would indicate that water would have a very large displacement pressure for petroleum. As Harkins and Livingston[2] have shown, if the necessity for mutual saturation of the phases (mentioned in connection with the discussion of Eq. 3) is neglected, this displacement pressure for water-heptane on silica would be 255 dynes per centimeter per centimeter of radius of the capillary through which flow is taking place. Actually, the small amount of water present in water-saturated heptane (or petroleum) would increase the spreading pressure of the oil phase considerably. The effect of small traces of water on the surface energy relations of organic liquids is well demonstrated in the work of Boyd and Harkins.[14] Some change in the spreading pressures must occur if the values are to fit the equation

$$\gamma'_{SF_2} - \gamma'_{SF_3} = \gamma_{F_2F_3} \cos \theta_{SF_2F_3} \quad [4]$$

(here the symbols γ' indicate the surface energy for mutually saturated phases). According to Eq. 4, the maximum value for $\gamma'_{SF_2}\gamma'_{SF_3}$ would be 51 dynes per cm. Therefore the difference between the spreading pressures must be greatly decreased because of the mutual saturation. For this reason, surface forces existing in multicomponent systems such as the petroleum reservoir will usually be much smaller than would be indicated from a study of simple two-component systems.

Intrusion of water into a gas sand involves the same relations as the intrusion of water into an oil sand. As Rowley and Innes have shown,[15] the surface energy relations at solid surfaces that have been covered with adsorbed molecules are almost the same, whether the molecules were adsorbed from a liquid or a gas.

It seems unlikely that the large contact angles found by Chapek and Krechun[13] actually hold for equilibrium conditions. For a single system (using mineral oil rather than heptane) they found variations in angle from 52° to 135°, depending on the previous treatment of the surface. Most workers[6] have assumed that this contact angle has a value of zero, and this seems the best value, in light of present information.

From this discussion, it can be concluded that water has a much greater thermodynamic pressure of spreading on silica than does a pure hydrocarbon, but, since under reservoir conditions the hydrocarbon phase is saturated with water, this great difference does not exist in the reservoir. Assuming that the contact angles involved are zero, the surface relations in the petroleum reservoir can be determined from the surface tension of the oil and the interfacial tension between the oil and the water, without consideration of the surface energy relations at the solid surface. Nevertheless, the knowledge that the spreading pressure of water is several times greater than that of hydrocarbons is of some importance.

Effect of Other Components

Some mention may be made of an additional factor whose effect on the surface energy relations of the petroleum reservoir is still completely unknown. This is the existence of other components, neither water nor hydrocarbons nor minerals, in the reservoir. These may be either the naturally occurring organic compounds—acids, aromatic derivatives, nitrogen or sulphur compounds—that exist in petroleum, or synthetic chemicals added in the course of production.

There is no information as to the effect of these substances on the spreading pressures or contact angles in the reservoir. It is known that many of them act to reduce interfacial tension. It is easy to demonstrate that the low interfacial tension of oil-water systems from petroleum reservoirs (as compared with the values for distilled water and heptane or refined petroleum fractions) is due to surface-active constituents in the petroleum. These substances undoubtedly act to increase the oil-water ratio that is obtained from producing sands (this is certainly true if they leave the contact angle unchanged at zero), for if the interfacial tension in the reservoir were 50 dynes per cm., instead of 35, the amount of water coexisting with oil at any particular horizon would be much greater.

In this connection, it should be mentioned that these surface-active agents seem to have considerable effect on the velocity of flow of oil and water through sands. Kussakov, Rehbinder, and Zinchenko[16] have demonstrated this in the course of a study of a natural petroleum and a pure hydrocarbon mixture of the identical viscosity. They have found that the natural petroleum with its surface-active components flows relatively less rapidly through oil-wet sand but more rapidly through water-wet sand. Thus it seems that the surface energy relations that have been discussed with regard to static phenomena such as capillary rise and displacement pressure also affect the dynamic phenomenon of flow through a porous medium.

Under some conditions, it would be desirable to enhance the effect of naturally occurring surface-active chemicals in the reservoir by adding greater amounts of such chemicals. Plummer, Hunter, and Timmerman[17] and Plummer and Livingston[18] have shown that addition of small amounts of synthetic wetting agents has a profound influence on the production characteristics of a certain type of model reservoir. Bonnet[19] has discussed certain field experiments with this method of improving production. These experiments show some promise but no large-scale success. One of the greatest difficulties in treating a reservoir with surface-active agents is the inaccessibility of the bulk of the reservoir liquid.

Another method of obtaining more advantageous surface energy relationships in the reservoir is to change the nature of the solid surface. On a solid of carbonaceous nature, a hydrocarbon would be expected to have about the same spreading pressure as water, and available data[2,4] indicate that this is true. Garrison[20] has devised several methods for coating sand grains with hydrophobe material. This procedure probably would be limited to use near the well bore.

APPLICATIONS

From the data presented, it is possible to reach certain conclusions that apply directly to problems of petroleum production. Some of these are as follows:

1. The spreading pressure of water on silica is 255 ergs per sq. cm. greater than the spreading pressure of a hydrocarbon (heptane) on silica. This indicates a displacement pressure of 37 lb. per sq. in. in a capillary of one micron radius. Actually the displacement pressure of water for silica is only one fifth as great, because of the fact that the difference in spreading pressures is only 51 ergs per sq. cm. when the two immiscible liquids are mutually saturated. The best data indicate that displacement pressures of water for oil in actual reservoirs are even smaller—roughly 5 lb. per sq. in. in a capillary of one micron radius.

2. The height to which water will rise into an oil sand will depend on the oil-water interfacial tension, contact angle, and radius of curvature of the capillaries in the sand. There is no accepted method of determining the radius of curvature of rock pores. An approximate method of solving Eq. 1 for the height of capillary rise of water in a sand would be as follows:

Introduce an extracted, dry core of the sand in question into a liquid of known surface tension and contact angle. By sectioning the core, determine the height at which the sand porosity is half filled with liquid. Using this figure (h_{50}), solve Eq. 1 for $\left(\frac{1}{R_1} + \frac{1}{R_2}\right)_{50}$. Then, using this value and the data for the reservoir fluids, solve Eq. 1 for the h_{50} of the reservoir, the height at which the oil sand is half saturated with water.

Similar determinations could be made to fix the region of one-fourth and three-fourths saturation, etc., so that the capillary rise throughout the reservoir could be approximately determined.

3. The surface energy relationships are directly applicable only to static phenomena such as capillary rise and displacement pressure. However, it has been observed that changes in these relationships may cause marked changes in rates of flow. This subject has not been sufficiently investigated.

4. Surface-active agents that decrease oil-water interfacial tension act to decrease capillary rise (and thus decrease the amount of water in an oil sand) and also to decrease the displacement pressure (and

presumably reduce the efficiency with which oil is removed from the reservoir).

5. Similar changes can be effected by changing the nature of the solid surface and thus changing the spreading pressure of water over the oil-covered solid surface.

CONCLUSION

Theoretically it is possible to determine the energy relations at the solid surface in the petroleum reservoir. However, this would be very difficult; the measurement of the interfacial tensions and contact angles is simpler and of equal value. Information as to the magnitude of the spreading pressure relations at the solid surface would be of interest, and such data have been presented.

The effect of surface-active substances, either naturally occurring or added in the course of production, seems to be very large. The influence of these substances on fluid flow through porous media is particularly worthy of further investigation.

ACKNOWLEDGMENT

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Permeability as a Function of the Size Parameters of Unconsolidated Sand

By W. C. Krumbein,* Member A.I.M.E., and G. D. Monk†

(Los Angeles Meeting, October 1942)

Abstract

The relation between permeability and the size parameters of unconsolidated sand is approached by considering sands as logarithmic frequency distributions having the basic parameters mean size and standard deviation. Sieve separates were mixed in accordance with the normal logarithmic probability law, so that the mean and standard deviation could be varied at will. Experiments were conducted in which one parameter was kept fixed and the other varied; in this manner the dependence of permeability on the individual parameters was evaluated. It was found that permeability can be expressed as the product of a power function of the mean size and an exponential function of the standard deviation.

Introduction

Earlier studies of the effect of size of particles on the permeability of unconsolidated sand have shown that the permeability varies with the square of some average diameter. This was first pointed out by Hazen[1] in 1892 and verified by Slichter[2] in 1898. Hazen's mean size was defined as the 10 percentile of the cumulative curve (i.e., size that is smaller than 90 per cent of the distribution and larger than 10 per cent). Slichter's effective size, on the other hand, was found by Wilsey[3,4] to agree with the 31 percentile. Fair and Hatch[5] found that the geometric mean size of sieve separates yielded the same power function; Hulbert and Feben[6] found that the permeability of sieve separates varied as the 1.89 power of the median diameter (i.e., the size associated with the 50 percentile of the cumulative curve).

Relatively few studies included the effect of the "sorting" of the sediment on the permeability. It was recognized that the nature of the size distribution, in terms of the spread of the particles about the mean, affects the permeability, but no systematic investigations of this effect are known to the writers. Cloud[7] demonstrated that the effect of the grain-size distribution on permeability is definitely measurable. In the present paper the authors investigate this relation analytically, and show that the effects of the size parameters on permeability may be predicted for at least a restricted set of conditions.

Properties of Sediments

Recent investigations have shown that essentially all the geologically important characteristics of sediments may be expressed in terms of six measurable quantities possessed by each clastic sedimentary particle. These attributes are: (1) size, (2) shape (sphericity), (3) roundness (angularity), (4) mineralogical composition (density), (5) surface texture, (6) orientation.

Each of these characteristics may be defined in several manners. Size may be expressed in terms of sieve mesh, settling velocity, volume, etc. Sphericity is a shape concept introduced by Wadell;[8] it is essentially a measure of the ratio of the surface area of an equivalent sphere to the surface area of the particle. The same

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[1] References are at the end of the paper.

author introduced the concept of roundness as the ratio of the average radius of the corners and edges of the particle to the radius of the inscribed circle within a projection of the particle. The mineralogical nature of the particle controls such attributes as hardness, density, color. The surface texture of a particle refers to the relative smoothness, pitting, or striations on its surface. The orientation, as the term is used here, refers to the directions of the principal axes of the particle with respect to coordinate axes fixed in space. The general subject of sedimentary properties and methods for their measurement is described by Krumbein and Pettijohn.[9]

In general, sedimentary deposits consist of populations of particles composing a stratum or bed. Within such a deposit the individual particles vary in size, shape, and other attributes, so that each of the characteristics is really present as a frequency distribution having as parameters a mean, a standard deviation, and perhaps higher moments. Thus, in the aggregate, the characteristics of natural sands and other sediments are expressible in terms of perhaps a dozen statistical parameters, depending upon which are considered of first-order importance. Among these statistical parameters, that of mean size is generally expressed as a length, whereas all the others may be kept nondimensional.

In addition to the properties of the individual particles, sediments in the aggregate possess certain macroscopic mass properties, such as porosity, permeability, strength under shearing forces. These mass properties depend to a large extent upon the combinations of particle properties present, plus given conditions of packing, water content, and so on. In practice it is convenient to determine the mass properties by direct experiment, but theoretically a study of the relation of mass properties to particle characteristics may shed considerable light on the principles underlying behavior of mass sediment.

PERMEABILITY AS A FUNCTION OF FUNDAMENTAL PROPERTIES OF SEDIMENTS

Several writers have shown that the constant of proportionality in Darcy's law includes several factors. The present development follows Hubbert's recent discussion of the subject.[10] Hubbert demonstrates that the constant has the following form:

$$K = \frac{Nd^2\rho g}{\mu} \qquad [1]$$

where K is the constant of proportionality in Darcy's original expression, ρ is the density of the fluid, g is the acceleration due to gravity, and μ is the dynamic viscosity of the fluid. The variables N and d, on the other hand, are properties of the medium. N is a dimensionless number, which includes a group of such factors as shape and packing, whereas d has the dimension [length], and is a size factor, associated either with the dimensions of the openings in the medium or expressible as a mean size of the particles. If the coefficient of permeability k be defined as

$$k = Nd^2 \qquad [2]$$

it will depend only upon the properties of the medium. This convention is followed here.

In the light of earlier work, which experimentally verified the dependence of k on the square of the grain diameter, the relation between k and various characteristics of the medium may be developed. Assume as a first approximation that size, shape, and packing of the grains are of first-order significance. Express the size and shape characteristics as the first two moments of the size and shape distributions. Then

$$k = f(d^2, \sigma_d, M_s, \sigma_s, H) \qquad [3]$$

where d^2 is the square of the average grain diameter, σ_d is the standard deviation of the size distribution, M_s is the mean shape (sphericity), and σ_s, is the standard deviation of the shape distribution. The factor H is a nondimensional packing parameter, expressed here as a single value, although in practice it may be possible to relate this to the shape and orientation parameters of the particles.

Dimensionally Eq. 3 reduces to [length]^2 = [length]^2, providing k is expressed as in Eq. 2, d is expressed as a length, and the other variables are kept in nondimensional form. Eq. 3 may be expressed nondimensionally by including the d^2 with k as follows:

$$k_n = k/d^2 = f_1(\sigma_d, M_s, \sigma_s, H) \qquad [4]$$

Here k_n may be called a "nondimensional permeability."

By taking the total differential of Eq. 4, the relations among the several rates of change are as follows:

$$dk_n = \frac{\partial k_n}{\partial \sigma_d} d\sigma_d + \frac{\partial k_n}{\partial M_s} dM_s + \frac{\partial k_n}{\partial \sigma_s} d\sigma_s + \frac{\partial k_n}{\partial H} dH \qquad [5]$$

Experimentally it is possible to keep all variables constant on the right-hand side except one, whereupon the effect of that variable on k_n may be evaluated. Such an approach was made implicitly by Tickell and Hiatt[11] with respect to the mean shape factor, and they showed that the permeability assumes a minimum value at intermediate values of the mean shape. In the present study the writers consider the size parameters only, so that shape factors and the packing effect (as well as such other nonexplicit factors as angularity and surface texture) are all kept as constant as possible during the experiments. On this basis, all the differentials vanish except those associated with size, and Eq. 5 reduces to

$$dk_n = \frac{\partial k_n}{\partial \sigma_d} d\sigma_d \qquad [6]$$

Eq. 6 forms the basis of the developments that follow.

Choice of Size Parameters

Many statistical measures are available for describing sediments (Krumbein and Pettijohn,[9] chapters 8 and 9). Among these, parameters based on logarithmic moments lend themselves to ready geometrical interpretation, owing to the symmetrizing effect of logarithmic plotting. Logarithmic moments were first introduced by Hatch and Choate[12] and by Wentworth.[13] The former defined their measures as log geometric moment measures and confined their work largely to the moments of logarithmically symmetrical curves that could be treated graphically. Wentworth used logarithmic methods for computing his moments, but referred to them as though they were arithmetic instead of logarithmic in nature. In 1936 the senior author[14] reopened the question by introducing an explicit logarithmic transformation equation, which related logarithmic moments to the body of conventional statistical theory. The transformation equation is

$$\phi = -\log_2 \xi \qquad [7]$$

where ξ is the diameter of the particle in millimeters. Subsequently he[15] showed that by using ϕ directly it was possible to set up a normal phi-probability curve, which possesses all the geometric attributes of the normal Gaussian curve as long as the phi notation is used throughout:

$$y = \frac{1}{\sigma_\phi \sqrt{2\pi}} e^{-\frac{(\phi - M_\phi)^2}{2\sigma_\phi^2}} \qquad [8]$$

In Eq. 8 the phi mean, M_ϕ, is the center of gravity of the logarithmic distribution, and σ_ϕ is the log standard deviation. It was also shown that the antilog of the phi mean is the geometric mean diameter in millimeters, GM_ξ:

$$M_\phi' = -\log_2 GM_\xi \qquad [9]$$

The work was extended to include measures of the logarithmic skewness and kurtosis, such that a logarithmic Gram-Charlier series could be set up for the analysis of size distributions. Otto[16] subsequently developed a graphic method for determining the parameters of the two-term phi Gram-Charlier series. The normal phi curve itself (Eq. 8) may be used directly with tables of the probability integral as found in standard reference books. Experience has shown that many natural sediments, including beach sand, dune sand, and even glacial outwash sand, tend to approximate the normal phi curve. Many other sediments are satisfactorily described by the two-term phi Gram-Charlier series.

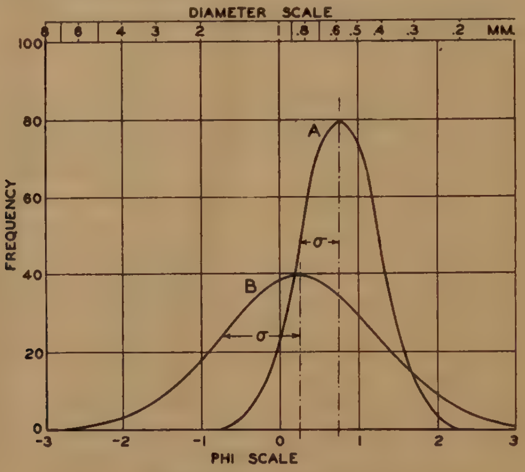

FIG. 1.—EXAMPLES OF NORMAL PHI CURVES.

Two examples of normal phi curves are shown in Fig. 1. The horizontal scale is expressed in phi units, and the corresponding diameter values are shown in the auxiliary scale at the top. One phi interval is equivalent to a geometric size interval based on the factor 2. For example, when $\phi = 0, 1, 2, \ldots,$ the corresponding diameter is 1, ½, ¼, . . . mm., respectively. Curve *A* in Fig. 1 has a phi mean (the maximum ordinate) at 0.75, which corresponds to a geometric mean diameter of about 0.59 mm. The phi standard deviation of this curve is 0.5. Curve *B* has a phi mean of 0.25, which corresponds to a geometric mean diameter of about 0.82 mm. The phi standard deviation of this curve is 1.0, so that the spread of the curve is twice that of curve *A*. It would be possible to superimpose the curves so that both have the same phi mean, and yet the properties of the curves would be different because of the different spreads. The significance of these two size curves in terms of permeability will be pointed out in a later section.

The normal phi curve, expressed in cumulative form, plots as a straight line on arithmetic probability paper when size is expressed as its phi equivalent. The slope of the line is proportional to σ_ϕ, and the phi value associated with the 50 per cent line is the phi mean. Graphically the phi standard deviation is found by subtracting the phi value at 50 per cent from that at the 84.1 per cent line.* These simple relations permit a convenient choice of parameters for normal phi curves, so that by mixing appropriate percentages of sieve separates, distributions having any average size and any degree of spread may be prepared.

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* This follows from the fact that in a normal curve 34.1 per cent of the distribution lies between the mean and a point one standard deviation to the right or left. The relation may be seen from any table of the probability integral.

EXPERIMENTAL PROCEDURE

The sand chosen for the permeability study was a glacial outwash sand of Wisconsin age. The shapes of its grains, expressed as their average sphericity value, was approximately 0.75, and the roundness was moderately low, approximately 0.50. Samples of the sand were sieved into $\sqrt[4]{2}$ size classes from 0.125 to 8.00 mm., which yielded 24 sets of separates for mixing into normal phi curves.

In mixing the separates, a straight line of predetermined slope was drawn on probability paper, the corresponding percentages were read from the graph, and these percentages were combined from the separates to form the desired distributions. In the first set the phi standard deviation, σ_ϕ, was kept fixed at 0.21 (a well-sorted sediment), and the phi mean was varied from minus 0.75 to 1.25. This corresponds to a range of geometric mean sizes from 1.69 to 0.42 mm. In the second set the phi mean was kept fixed at zero (geometric mean diameter = 1.00 mm.) and σ_ϕ was varied from 0.15 to 0.80, to represent a moderately wide range of sand sorting. The two sets of curves are shown in Fig. 2. The parallel lines all have the same phi standard deviation, and the radiating lines all have the same phi mean. The statistical parameters of the distributions are given in Table 1.

The original permeability measurements were made by the junior author in the preparation of a dissertation for the master's degree at the University of Chicago.[17] The apparatus used in the study was a variable-head permeameter of the type developed by Fishel and Stringfield.[18] Subsequently it was found that for sands having a mean size above about 0.75 mm. the velocity of water passage through the sand forced the Reynolds number associated with the flow to become greater than 5. This is near the upper limit of validity of Darcy's law,[10] so that the experiments were repeated with a constant-head permeameter. For fine sediments, the two types of equipment gave results in good agreement, but with coarse sediments the variable-head permeameter gave lower values than the constant-head equipment.

TABLE 1.—*Statistical Parameters and Permeability Coefficients of Sieve Separates and Normal Phi Distributions*[a]

Sample No.	Phi Mean	Phi Standard Deviation	Geometric Mean Diameter, Mm.	Permeability, Darcys
a	1.88	0.04	0.273	57.0
b	1.63	0.04	0.324	60.5
c	1.38	0.04	0.38	89.3
d	1.13	0.04	0.46	139
e	0.88	0.04	0.55	207
f	0.63	0.04	0.65	298
g	0.38	0.04	0.77	403
h	0.13	0.04	0.92	615
i	−0.13	0.04	1.09	812
j	−0.38	0.04	1.30	1195
1	1.25	0.21	0.42	106
2	1.00	0.21	0.50	148
3	0.75	0.21	0.59	213
4	0.50	0.21	0.71	275
5	0.25	0.21	0.84	401
6	0.00	0.21	1.00	590
7	−0.25	0.21	1.19	810
8	−0.50	0.21	1.41	1120
9	−0.75	0.21	1.69	1555
10	0.00	0.15	1.00	618
11	0.00	0.21	1.00	590
12	0.00	0.28	1.00	520
13	0.00	0.34	1.00	470
14	0.00	0.40	1.00	465
15	0.00	0.47	1.00	430
16	0.00	0.53	1.00	361
17	0.00	0.61	1.00	355
18	0.00	0.66	1.00	311
19	0.00	0.74	1.00	294
20	0.00	0.80	1.00	257

[a] Permeability values for porosity of 40 ± 0.5 per cent.

The constant-head permeameter consisted of a vertical Lucite tube 4.4 cm. in diameter and 30 cm. high. Manometer outlets were arranged 20 cm. apart. A fine mesh screen was set near the bottom of the tube, and the depth of sand was sufficient to extend above the upper manometer outlet. The constant-head tank was adjusted for each run, and the rate of flow was kept sufficiently small so that the Reynolds number remained less than one as far as possible. The water flowed vertically upward through the sand, and the discharge was measured in a graduated cylinder.

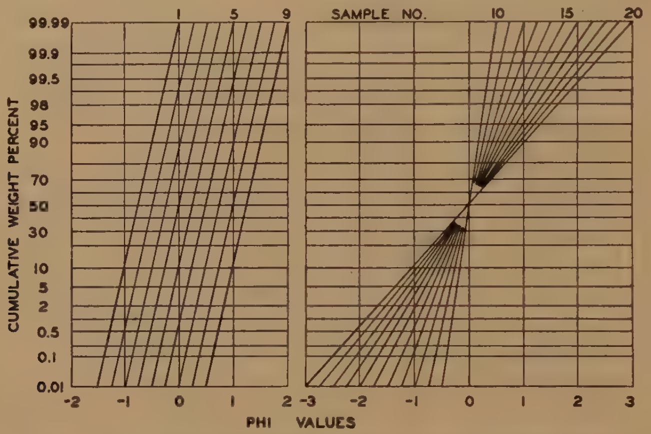

FIG. 2.—SIZE DISTRIBUTIONS OF SAND USED IN EXPERIMENTS.

The equation used in the experiments was

$$Q = KA\frac{\Delta h}{s} \qquad [10]$$

where Q = discharge in c.c. per sec; A = cross-sectional area of cylinder in sq. cm.; Δh = difference in manometer readings in cm.; s = distance between manometer outlets in cm.; and K = coefficient of permeability in c.c. per sq. cm. per sec. As measured, the permeability coefficient K has the dimensions [length]/[time]. This unit was transformed to darcys, which have the dimensions $[\text{length}]^2$. For water at 20°C., the transformation factor has the numerical value 1040 (p. 72 of ref. 19).

Experiments were run with a number of the sieve separates to see whether the results agreed with earlier findings to the effect that permeability varies with the square of the diameter. The mean size of each separate was expressed as the geometric mean of the limiting sieve sizes; thus the average size of grains in the sieve range 0.991 to 0.84 mm. is $\sqrt{(0.991)(0.84)} = 0.92$ mm. Several runs were made on each of the normal phi distributions also, and the results were averaged to obtain the mean permeability. All permeability measurements were made at a constant porosity of 40 per cent, as far as that could be controlled. The sand was poured into the water-filled permeameter during constant tapping with a rubber-tipped mallet. By tapping until a known weight of sand filled the permeameter to a predetermined reference mark, the porosity could be controlled to within about 0.5 per cent. The porosity relation used was

$$\text{Porosity} = \frac{V_b - V_g}{V_b} \times 100 \qquad [11]$$

where V_b is the bulk volume and V_g is the grain volume. The specific gravity of the sand was 2.66.

INTERPRETATION OF THE DATA

The complete experimental data are summarized in Table 1. The individual separates are listed as *a, b, c,* . . . and the normal size distributions are numbered in accordance with the curves in Fig. 2. The table includes the statistical parameters of the distributions. The phi standard deviation of the sieve separates is taken as 0.04, which is one sixth the phi interval between the sieves.*

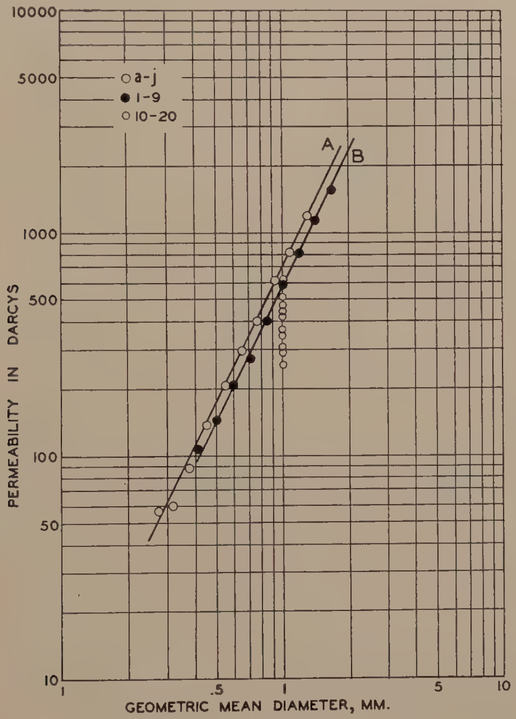

FIG. 3.—EXPERIMENTAL DATA.

Fig. 3 is a graph of the data of Table 1 on double log paper. Straight line *A* is drawn through samples *a* to *j*; line *B* is drawn through samples 1 to 9; and the vertical row of circles along the 1-mm. axis represents samples 10 to 20. The slopes of the two straight lines are very nearly 2.0, verifying the earlier theoretical and observed relation that permeability varies as the square of the diameter. This statement must be qualified, however, to include the necessary condition that the spread of the size-distribution curves remains essentially constant in any one series. The fact that samples 1 to 9 lie in a lower region of the graph than samples *a* to *j* indicates the effect of an increased standard deviation on the permeability. Earlier workers have noted that different sets of data plot as parallel straight lines, but the writers are not aware that the correct reason for this was previously discerned.

The vertical row of small circles in Fig. 3 shows even more strikingly how the permeability is affected by the standard deviation. These points all represent sands with a mean diameter of 1 mm., and essentially constant porosity, and yet the permeability decreases from 618 to 257 darcys over a range of σ_ϕ from 0.15 to 0.80.

The effect of the phi standard deviation on permeability is brought out more clearly in Fig. 4. Here the permeability is plotted against σ_ϕ on semilog paper. The straight line is a satisfactory fit, and indicates an exponential relation. Inasmuch as the mean size of all the samples is 1.00 mm., the effect shown on the graph is wholly due to increasing spread of the size distributions.

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* It is assumed that the grains within any one sieve range are logarithmically distributed. In general, one standard deviation unit is approximately one sixth the range over a normal curve.

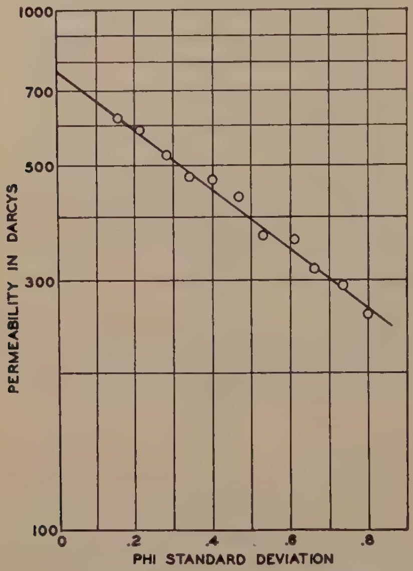

FIG. 4.—PERMEABILITY AS A FUNCTION OF THE LOGARITHMIC STANDARD DEVIATION.

In order to relate the experimental data to the theoretical development in Eqs. 1 to 6, the original notation may be modified in terms of the statistical parameters used. The symbol k represents the permeability in darcys, the symbol d is the geometric mean diameter in millimeters, GM_ξ, and the symbol σ_d represents the phi standard deviation σ_ϕ. In the transformed notation, Eq. 6 may be written more fully as

$$d(k/GM_\xi^2) = dk_n = \frac{\partial k_n}{\partial \sigma_\phi} d\sigma_\phi \qquad [12]$$

If an expression can be found for $\frac{\partial k_n}{\partial \sigma_\phi}$, it will be possible to integrate Eq. 12 and obtain a general expression for permeability in terms of both mean size and standard deviation.* Inasmuch as GM_ξ is 1.00 mm. in samples 10 to 20, the ordinates in Fig. 4 may be considered as $k_n = k/GM_\xi^2$, which have the same numerical value. From the graph, the relation between the nondimensional permeability and σ_ϕ may be written as $\log k_n = -a_1\sigma_\phi + a_2$. Taking antilogs of the natural logarithms yields the expression

$$k_n = e^{-a_1\sigma_\phi + a_2} = e^{a_2}e^{-a_1\sigma_\phi} \qquad [13]$$

Eq. 13 may be differentiated to yield the partial derivative

$$\frac{\partial k_n}{\partial \sigma_\phi} = -a_1 e^{a_2} e^{-a_1\sigma_\phi}$$

in which substitution from Eq. 13 gives the following:

$$\frac{\partial k_n}{\partial \sigma_\phi} = -a_1 k_n \qquad [14]$$

By substituting this relation in Eq. 12, the differential equation can be solved directly. The following steps indicate the procedure:

$$dk_n = -a_1 k_n d\sigma_\phi$$

$$\frac{dk_n}{k_n} = -a_1 d\sigma_\phi$$

$$\log_e k_n = -a_1\sigma_\phi + C$$

To evaluate the constant of integration C, let $\sigma_\phi = 0$, whereupon $C = \log_e (k_n)_0$. Hence

$$\log_e k_n = -a_1\sigma_\phi + \log_e (k_n)_0$$

Take antilogs

$$k_n = (k_n)_0 e^{-a_1\sigma_\phi} \qquad [15]$$

Substitute back for k_n in terms of k and GM_ξ, and solve for k, to obtain the general relation

$$k = \left(\frac{k}{GM_\xi^2}\right)_0 GM_\xi^2 e^{-a_1\sigma_\phi} \qquad [16]$$

This final relation indicates that the permeability is proportional to the product of the square of the geometric mean diameter and the negative exponential of the logarithmic standard deviation, for size distributions that satisfy the normal logarithmic probability law. The constants $(k/GM_\xi^2)_0$ and a_1 may be evaluated for the present experiments from Fig. 4. The first constant is the value of the ordinate at $\sigma_\phi = 0$, which is seen to be 760. The coefficient a_1 is found by standard methods (p. 210 of ref. 9) by taking the "half-value" of the ordinate and dividing it into 0.693. This procedure gives $a_1 = 1.31$. The general expression of Eq. 16 may therefore be written more specifically as

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* It is possible to obtain such a relation directly from the experimental data of Figs. 3 and 4. However, the detailed steps involved in the mathematical procedure are given here in order to indicate more clearly the nature of the constants involved.

$$k = 760 GM_\xi^2 e^{-1.31\sigma_\phi} \qquad [17]$$

for the present experimental data. Both the constants and σ_ϕ are nondimensional, so that the equation reduces to the dimensions $[\text{length}]^2 = [\text{length}]^2$. The numerical value of the constants, however, depends upon the units used in measurement.

Eq. 17 may be used to account for the relative positions of the two parallel lines in Fig. 3. Both curves are of the general form $\log k = 2 \log GM_\xi + \log c$, which may be written as $k = c(GM_\xi^2)$. If the constant c is evaluated at $GM_\xi = 1.00$ mm., the constants have the values 690 for the sieve separates and 590 for the normal curves. The separates have a fixed $\sigma_\phi = 0.04$, so that the exponential factor in Eq. 17 becomes $e^{-0.05}$, which has the value 0.95. Hence for the sieve separates, the calculated equation for the curve of Fig. 3 is $k = 720(GM_\xi^2)$, which agrees within about 6 per cent with the observed value. Similarly, the normal curves in Fig. 3 have a fixed $\sigma_\phi = 0.21$, so that the negative exponential becomes $e^{-0.276}$, which has the value 0.76. Hence, for the normal curves the calculated equation is $k = 580(GM_\xi^2)$, which agrees within about 2 per cent with the observed value.

This development indicates that the relative positions of given sets of data on graphs similar to Fig. 3 may be predicted reasonably well, providing that the other variables—such as shape, packing, per cent porosity—are kept reasonably constant, and providing that the distributions satisfy the condition that they are logarithmically normal.

TABLE 2.—*Comparison of Observed and Calculated Permeabilities of Wilsey's Data*[a]

Wilsey Sample	Observed Permeability		Geometric Mean, Mm.	σ_ϕ	Calculated Permeability from Eq. 17	Error, Per Cent[b]
	K Units	Darcys				
2	3.23	3,360	2.90	0.55	3,130	− 6.8
3	1.58	1,642	2.15	0.56	1,685	2.6
4	0.86	895	1.52	0.60	797	−10.9
5	0.425	442	1.10	0.54	452	2.3
6	0.181	188	0.77	0.55	227	20.7
7	0.0823	85.6	0.54	0.60	101	18.0
8	0.0489	50.9	0.40	0.60	55.2	8.4

[a] Porosity ranges from 40 to 42 per cent. No corrections made.

[b] Error calculated as percentage from (obs.-calc.)/obs.

An independent verification of the form of Eq. 16 may be had by considering data taken from Wilsey.[3] Wilsey mixed a number of artificial sands in such a manner that the mean size varied but the spread of the curves remained fixed. The writers plotted these data on probability paper and found that they yielded straight lines, which permitted a re-evaluation of their parameters in terms of the phi notation. The new values were used with Eq. 17, by comparing the permeabilities calculated from the equation with the values observed by Wilsey. The results are shown in Table 2. The average error is only about 10 per cent, despite the fact that Wilsey's data involve porosities from 40 to 42 per cent and that the constants for his sand may not have been the same as the writers'. However, Wilsey's sand was also of glacial outwash origin, and the shape factor may have been of the same order of magnitude. Wilsey's data also plot as a straight line of slope 2 on a graph similar to Fig. 3. A check of the position of the line shows that the equation is $k = 345(GM_\xi^2)$. From the average value of $\sigma_\phi = 0.57$, the exponential in Eq. 17 becomes $e^{-0.75}$, which has the value 0.47. Hence the calculated equation is $k = 360(GM_\xi^2)$, which agrees within 5 per cent with the observed value. Wilsey's original permeability data are given in *K*-units, which were converted to darcys for the calculations.

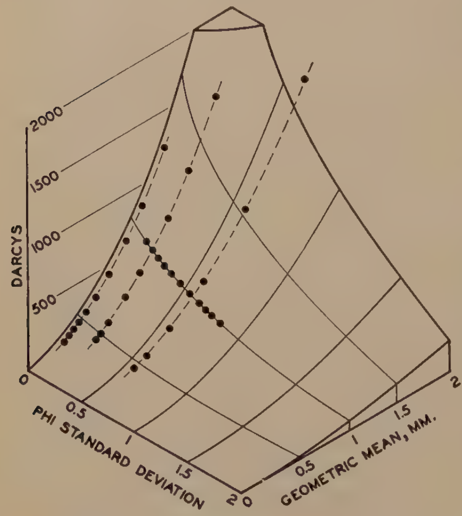

FIG. 5.—PERMEABILITY SURFACE.

PERMEABILITY SURFACE

The mutual control of permeability by the mean size and standard deviation may be brought out by considering the surface generated by Eq. 17. Fig. 5 shows this surface over a range somewhat larger than that covered by the experimental data. The vertical axis represents the permeability in darcys, and the horizontal axes are the geometric mean diameter in millimeters and the phi standard deviation. The scales of the horizontal axes are equal, but larger than the vertical axis, to bring out details of the slope. The nature of the surface is shown by the grid lines, which are parabolas parallel to the darcy-size plane, and negative exponentials parallel to the darcy-standard deviation plane. The points drawn on the surface represent the experimental data, including Wilsey's data.

From the nature of the surface, it is obvious that as the spread of the size-distribution curve increases (along the increasing σ_ϕ axis), experimental points with any given set of sands intersect successively lower parts of the surface. This is a visual presentation of the spacing of such lines as are shown in Fig. 3. It may also be noted that the slopes of the exponential components are about as steep as those of the parabolic components, indicating that the effect of one phi standard deviation unit is of about the order of magnitude of a millimeter unit on the size scale.

Although they are not shown, it is possible to sketch contour lines on the permeability surface, each of which represents a line of equal permeability—an isoperm. The nature of these contours, which lie horizontally, may be investigated by setting *k* in Eq. 17 equal to some fixed value, as 1000 darcys. Then Eq. 17 becomes $1000 = 760\ (GM_\xi^2)e^{-1.31\sigma_\phi}$, which may be simplified to

$$(GM_\xi^2) = 1.32e^{+1.31\sigma_\phi} \qquad [18]$$

Eq. 18 indicates that the contours are positive exponentials, and that successive contours would differ only in the value of the constant 1.32. From Eq. 18 may be calculated the combinations of size and sorting that yield a fixed permeability. As an example, consider two size curves of $\sigma_\phi = 0.5$ and 1.0. When $\sigma_\phi = 0.5$, $GM_\xi = 0.59$ mm.; and when $\sigma_\phi = 1.0$, $GM_\xi = 0.83$ mm. The first of these size distributions extends from about 2 to 0.2 mm., and the second ranges from about 8 to 0.1 mm.* (Refer back to Fig. 1 for illustrations of the two distributions.) In this example the larger mean is 1.4 times as great as the other, and has twice as large a spread, and yet the permeability is the same. The example chosen is by no means an extreme; by choosing other contours on the permeability surface a first approximation at least may be had of the mutual effects of mean size and degree of spread on permeability.

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* The range of sizes associated with any value of σ_ϕ may be roughly determined by recalling that a normal curve extends about three standard deviations on either side of the mean.

It should be pointed out explicitly that the permeability surface applies only to logarithmically normal size distributions of fixed porosity, and as far as the experimental evidence goes, with no particles finer than about 0.25 mm. Whether natural sands, with fine material well into the silt range, will give similar results, was not tested. Similarly, the effect of skewness, which frequently is present in natural sand, would be to complicate this simple surface. Skewness may be either positive or negative, with the result that the size distribution may have a "tail" either toward the fine end of the distribution or toward the coarse end. It is not anticipated that the effect on permeability would be the same in the two instances. The senior author hopes to extend present work to include natural skewed-sand distributions, which should be amenable to a similar line of attack.

SUMMARY

The present paper demonstrates that the size factors that control permeability may be evaluated experimentally and analytically. Although no conclusions that apply generally to natural sands can be reached, it is believed that the present development at least indicates the nature of the controlling functional relationships, and the order of magnitude of the effects involved.

The present findings may be integrated with the fundamental relations given in Eqs. 1 and 2. Eq. 1 shows that a number of factors may be included in the N, providing only that they be kept in nondimensional form. The present study isolated the effect of the spread of the size distribution under the condition that other nonexplicit factors in N be kept constant. With this condition, Eq. 2 may be reexpressed as $k = N'd^2e^{-a_1\sigma_\phi}$, where N' now retains the remaining factors, including shape, packing, skewness, and other properties. The geometrical mean diameter may also be substituted for the somewhat noncommittal d, inasmuch as the dimensions are the same.

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The Use of Electrode Spacing in Well Logging

By Richard H. Zinszer,* Junior Member A.I.M.E

(Los Angeles Meeting, October 1942)

Abstract

Application of electric logs has been used in correlation of subsurface structure to determine the size and shape of the oil reservoir. Such a knowledge is hardly complete until saturation and productivity are determined for the various horizons. It is difficult to use electric logs successfully for this purpose because of the many factors that influence the curves. In this work an effort was made to establish an empirical correlation between formation resistivity for a series of electric-log curves and water saturation and oil productivity of sand. Electric logs were obtained by recording with 10 different electrode spacings through the same interval of a well. In the analysis of these curves all factors except two, a dependent and independent variable, were held constant. The interval studied had been cored and a large number of samples were analyzed in the core laboratory in order to compare the values of permeability and saturation with the measured values of formation resistivity.

Results of this analysis indicate: (1) the depth to which mud filtrate enters a sand body, (2) a correlation between permeability and sand resistivity for shallow penetration depths, and (3) that the water saturation for an oil sand can be determined from the measured sand resistivity after making suitable corrections for sand thickness. The proceduer in the last method depends on a correction for thickness factor and a theoretical curve. The accuracy of the theoretical curve is now being tested in the laboratory.

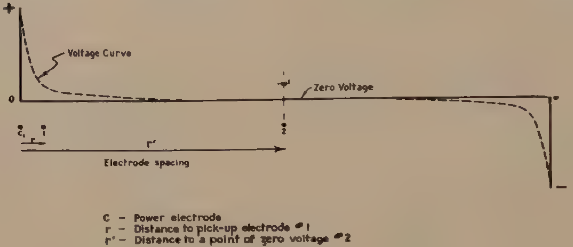
+
Voltage Curve
0
Zero Voltage
C₁
1
2
r
r'
Electrode spacing
–
C – Power electrode
r – Distance to pick-up electrode #1
r' – Distance to a point of zero voltage #2

Fig. 1.—Typical voltage curve.

Introduction

In an effort to place the analysis of electric logs on a quantitative basis, there is need for a better understanding of the many factors that influence an electric-log curve. These factors may be large differences in sand thickness, permeability of the sand, salinity of the interstitial water, mud resistivity, formation temperature, and other sources. A number of examples were presented by Archie,[1] which treat the effect of sand thickness on measured resistivity. He compared the true resistivity of a sand with the observed resistivity for sands 8 ft., 16 ft., and 24 ft. thick, and found the observed resistivity of the 8-ft. sand to be approximately

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[1] References are at the end of the paper.

50 per cent of the true resistivity. He also developed an equation involving the formation factor that is used to calculate water saturation in thick sand bodies.

In the present work the thicknesses of the majority of the sands ranged from 1 to 10 ft., with only one 30-ft. sand. All of the data were obtained from one well in the Rosecrans oil field, California. This variation in sand thickness is typical of the producing horizons in California and no doubt accounts for the slow progress in the quantitative analysis of electric logs. The present study appears to lend itself to a statistical correlation because of the large number of thin sands cored and analyzed. Laboratory tests are still in progress to determine the accuracy of one curve presented in the report, which relates the resistivity of a sand to the percentage of water saturation at several salinities.

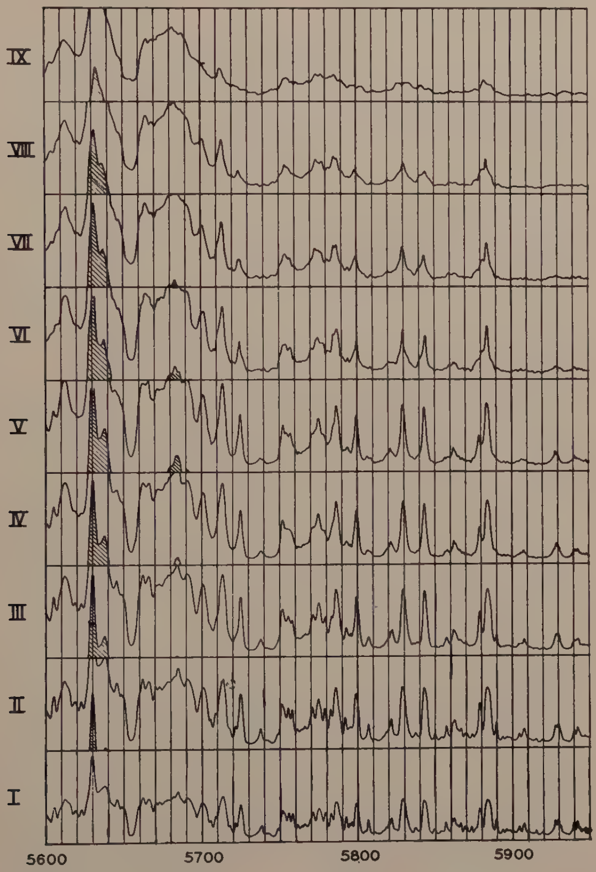

FIG. 2.—RESISTIVITY CURVES FOR SEVERAL ELECTRODE SPACINGS.

On initiating the experimental runs, electrode spacings were increased from 5 in. to 89 in., through a large number of increments, in an effort to follow the change in measured resistivity to points beyond the distance to which mud filtrate would enter a sand body. In addition, the many thin sand bodies encountered during coring presented an opportunity to relate sand thickness to the measured resistivity.

EXPERIMENTAL DATA

The well chosen for the experiment was cored continuously from 5550 to 6447 ft. At intervals in this operation it became necessary to stop the coring in order to ream the hole. The time from the start of coring at 5550 ft. to the running of the electric log amounted to 12 days, during which period the upper portion of the cored hole was subjected to 11 round trips of the bit, as compared with one round trip for the lower part of the hole. Circulation of mud was continued 4 hr. after the last core was taken, in order to ensure a uniform conditioning of the mud.

TABLE 1.—*Electrode Spacing and Depth of Penetration*

Curve No.	Electrode Spacing, In.		Depth of Penetration (D. P.), Ft.
	r	r'	
1	5	600	0.83
2	10	600	1.64
3	15	600	2.43
4	20	600	3.22
5	25	600	4.00
6	35	600	5.50
7	40	600	6.20
8	47	600	7.30
9	63	600	9.50
10	89	600	12.90

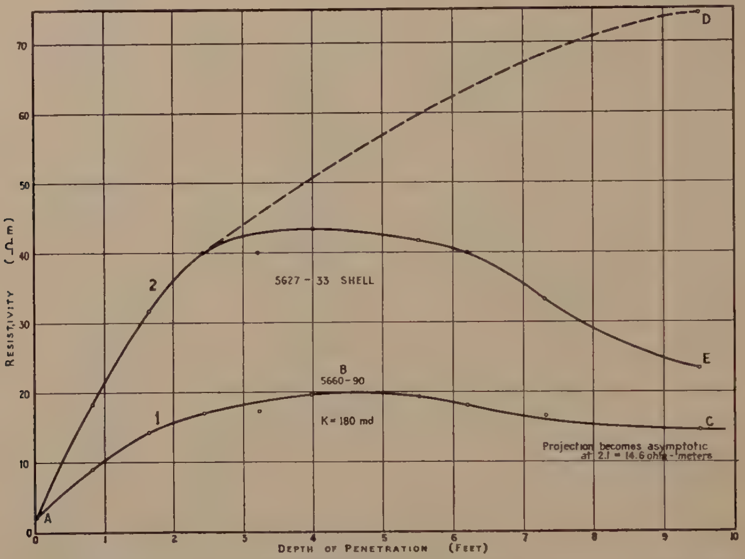

FIG. 3.—COMPARISON OF MEASURED RESISTIVITY FOR A THICK SAND AND A THIN SHELL.

Table 1 lists the electrode spacings used in this electric-log survey for a single potential and single pickup device.

Fig. 1 illustrates the positions of the electrodes with respect to a simple voltage curve that might exist in a homogeneous formation. The present use of the term "depth of penetration" referred to in Table 1 is a relative expression for comparing the effect of the electrode spacings.[2] This expression determines an approximate distance in a homogeneous formation to a point at one-half the voltage between that of r (distance to the pickup electrode No. 1) and that at r' (distance to a point of zero voltage No. 2). This can be expressed by:

$$D.P. = \frac{2rr'}{r + r'}$$

This equation gives a practical concept to the effect of electrode spacing, which can be readily used for correlating.

Table 2 lists pertinent data relating to the test. It should be noted that the mud temperature of 160°F. differs from the formation temperature of 188°F. The difference is caused by circulating the mud before running the electric-log survey. The salinity of the interstitial water was assumed to be the same as the salinity of the produced water (1575 grains per gal.).

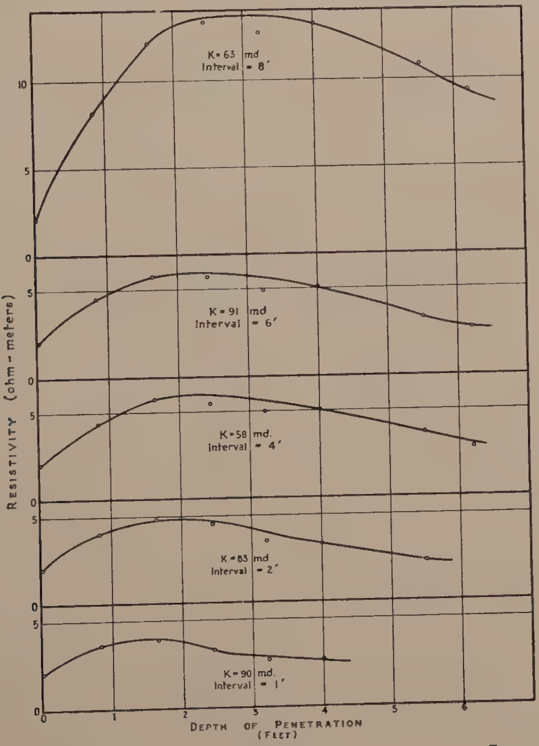

FIG. 4.—RESISTIVITY VS. DEPTH OF PENETRATION FOR SAND BODIES OF DIFFERENT THICKNESSES.

TABLE 2.—*Pertinent Data*

AT TIME OF SURVEY

Formation temperature, 188°F.
Mud resistivity, 4 ohms per meter, temp. 77°F.
Mud resistivity, 2 ohms per meter, temp. 160°F.
Mud loss, 4.3 cc. 5–15 min.
Mud weight, 76 lb. per cu. ft.
Mud salinity, 35 grains per gal.

ON COMPLETION

Production index, 1.0
Static pressure, 300 lb.
Gas-oil ratio, 3700
Initial cut, 37.0 per cent
Salinity, 1575 grains per gal.

Curves corresponding to electrode spacings tabulated in Table 1 were arranged in Fig. 2 so that absolute values of resistivity could be measured at any depth.

As already explained, each curve is a measure of the formation resistivity, using different penetration depths. The majority of the data used in the following correlations were obtained from Fig. 2 by measuring values of resistivity for a sand from the respective curves and repeating this procedure for all the sand bodies cored and analyzed. On plotting the value of sand resistivity for each electrode spacing with the corresponding depth of penetration, a typical curve was obtained (curve I, Fig. 3).

RESISTIVITY-PENETRATION DATA AND PERMEABILITY CORRELATIONS

Point *A* in Fig. 3, curve I, is the resistivity of the mud corrected for temperature.[3]

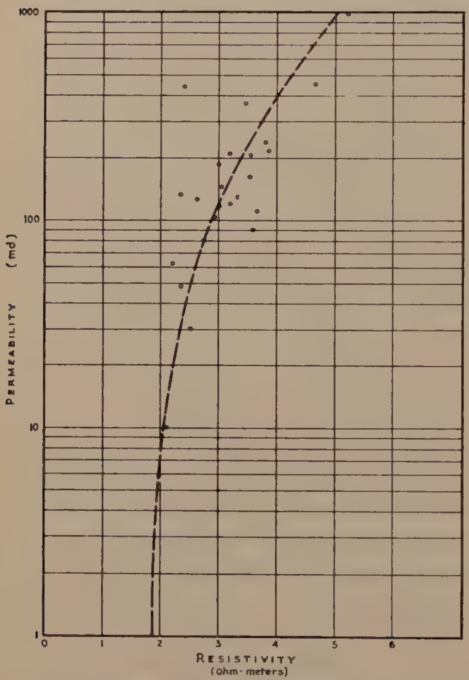

Fig. 5.—Permeability-resistivity relation for 5-inch electrode spacing and average sand thicknesses of 0.75 feet.

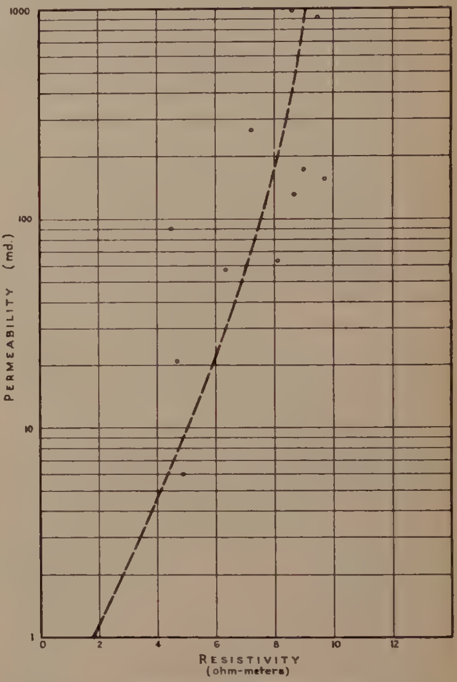

Fig. 6.—Permeability-resistivity relation for 5-inch electrode spacing and average sand thicknesses of 6.8 feet.

With greater depths of penetration the values of resistivity increase until *B* is reached. This increase in measured resistivity is caused by the decreasing influence of the fluid in the borehole as a result of greater penetration depths, and also by the infiltration of fresh water which displaces some oil and dilutes the salinity of the interstitial water. Infiltration of fresh water tends to increase the measured resistivity above the sand resistivity approximated by the value at *C*. Curve II, Fig. 3, is a comparison to scale of the increase in resistivity with depth of penetration for a thin calcareous shell. In coring this interval there was some lost recovery of the shell, therefore its thickness was estimated from the shallow penetration curve of the electric log. The dotted line to the point *D* is an estimate of what would have been recorded for a shell of substantial thickness (Fig. 3, curve II). The decrease in the measured curve for resistivity along *E* is due to an averaging with adjacent bodies having a lower resistivity.[9] A more detailed discussion of the thickness factor curve will follow later. In Fig. 4, a number of curves for resistivity versus depth of penetration for sand bodies of varied thickness but of nearly the same average permeability are plotted. The maximum position of resistivity on the curves shifts to shallower penetration depths for the thinner sand bodies. This shift is not a true measure of the relative penetration of the infiltrated fluid, but is again the averaging effect of adjacent bodies of lower resistivity. Decrease in resistivity of a thick sand as illustrated by curve I, Fig. 3, where the position of the peak on the penetration curve is less than one-half the thickness of the sand body, establishes the limits of penetration of the mud filtrate. This is because the sand body is so thick that the influence of adjacent bodies with low resistivity are of minor importance.

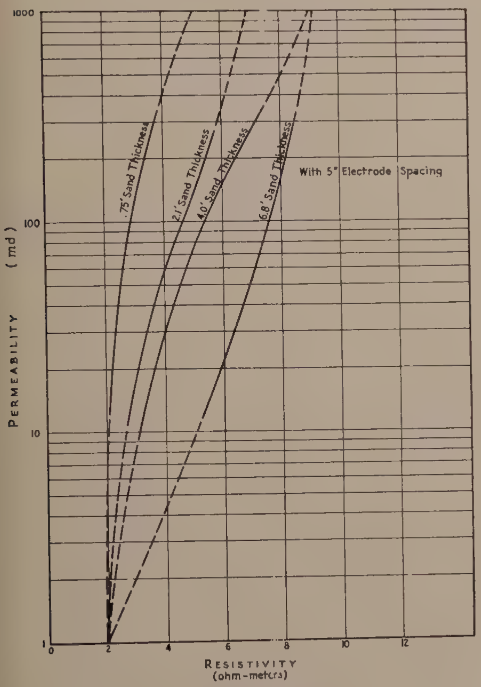

Fig. 7.—Permeability-resistivity relation for 5-inch electrode spacing and average sand thicknesses of 0.75, 2.1, 4.0 and 6.8 feet.

Fig. 4 is a plot of penetration curves for several sand bodies having comparable permeability and differing in sand thickness. At a common penetration the values of resistivity become increasingly large for the thicker sands. With permeability constant, this would suggest that measured resistivity is a function of sand thickness. Since interstitial water saturation is a function of permeability, as established by Schilthuis,[4] and resistivity is a function of saturation, measured resistivity is then a function of sand thickness and permeability. To establish these correlations it becomes necessary to keep one of the variables constant. In the following analysis the sand thickness is held constant.

In Figs. 5 and 6 are illustrations of the scattering of points when an electrode spacing of 5 in. and sand thicknesses of 0.75 and 6.8 ft. are used.

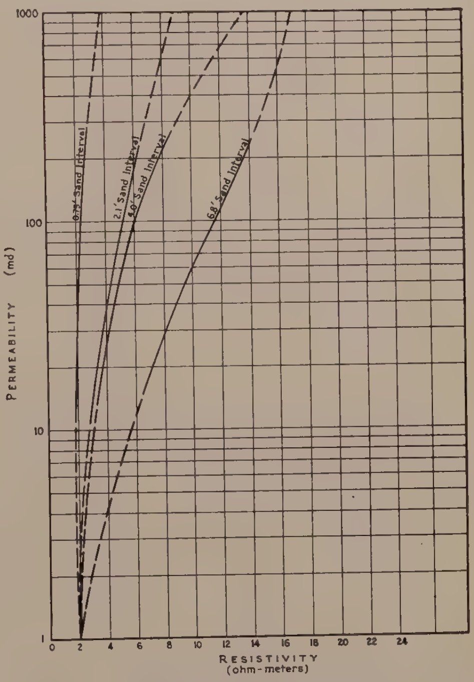

Fig. 8.—Permeability-resistivity relation for 20-inch electrode spacing and average sand thicknesses of 0.75, 2.1, 4.0 and 6.8 feet.

Fig. 7 is a composite of this type of curve for all the sands considered. In the construction of the curves they appeared to converge. A permeability of 1 md. and an average resistivity for 10 shale bodies of varied thickness was chosen as the point of convergence.

The permeabilities of the shales are not known, so the curve could have ended at 0.1 md. or 0.01 md. In either case this would cause little change in the curves at larger values of permeability. The regions of uncertainty are therefore drawn as broken lines. The average number of permeability samples obtained per plotted point were 1.07, 1.83, 2.72, and 4.4, respectively, for the sands 0.75, 2.1, 4, and 6.8 ft. thick. An arithmetic average was used in every case for determining the permeability. In a number of instances this included a very wide range of individual permeability values and it is believed that a portion of the scattering in Fig. 5 is due to an insufficient number of permeability values (per plotted point). To supply the present core-analysis data, 286 samples were taken for the testing of permeability, porosity and saturation. Another correlation was constructed using 20-in. electrode separation, commonly referred to in California as the normal electrode spacing (Fig. 8). This again shows a composite of the several sands considered.

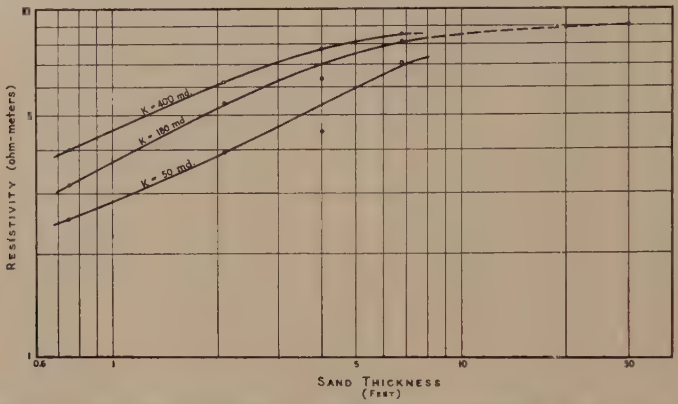

FIG. 9.—RELATION BETWEEN RESISTIVITY AND SAND THICKNESSES USING 5-INCH ELECTRODE SPACING.

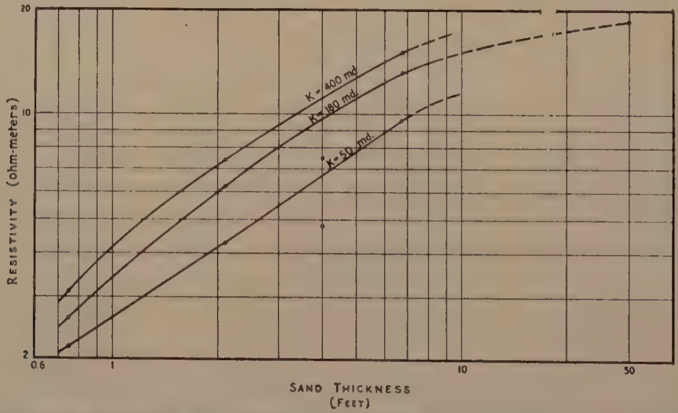

FIG. 10.—RELATION BETWEEN RESISTIVITY AND SAND THICKNESS USING 20-INCH ELECTRODE SPACING.

The measured resistivity value taken from the curves with this electrode spacing lies below the plotted trend on nearly all the resistivity-penetration curves, Fig. 4, D. P. = 3.22 ft. It was necessary therefore to choose a value of resistivity from the trend rather than that measured. It became evident that a correlation with the 20-in. spacing would not be as good as that with the 5-in. spacing. This can be illustrated best by referring again to Fig. 4, where the values for 0.75-ft. and 2.1-ft. sands are chosen on the decreasing side of the resistivity curve while the value on the 8-ft. sand is taken from the peak of the curve.

The curve of the 4-ft. sand in both Fig. 7 and Fig. 8 lies too close to that of the 2-ft. sand. Original data on the 4-ft. sand did not correlate as well as those for the other sands, therefore its present position may be in error. A cross plot of the curves in Figs. 7 and 8 at constant permeability are shown in Figs. 9 and 10.

For a permeability of 180 md. the curve was extended to 30 ft. Here again the points of the 4-ft. sand appear low. The trend of the 180-md. curve influences the construction of the 50-md. curve whereby little value is placed on the 4-ft. point. These curves illustrate the effect of thickness on the measured resistivity of a sand. The increased slope of the curves for a 20-in. electrode spacing as compared with the curves for a 5-in. electrode spacing probably is caused by the greater influence of mud resistivity on the shallow 5-in. penetration.

It should be remembered that the curves for the 5-in. and 20-in. electrode spacings are made from electric-log surveys in a single well. Since the measured resistivities are for shallow penetrations, the curves are subject to change through the effect of mud resistivity and size of the well bore. In the use of these curves consideration must be given to these factors.

Calculation of Water Saturation for Several Sands

So far this discussion has dealt largely with an analysis of the depth-penetration curves in the region of infiltration. To determine water saturation of large sand bodies from resistivity it is necessary to know the relation between sand resistivity and water saturation. A series of theoretical curves (Fig. 11) was constructed to offer this utility, and these curves are now being checked by laboratory tests. A formation factor was calculated for shales:

$$F = \frac{\text{resistivity of shale (assumed 100 per cent saturated)}}{\text{resistivity interstitial water}}$$

$$= \frac{1.8}{0.105} = 17$$

Measured resistivity of the interstitial water at 188°F. agrees closely with the calculated value. It was possible therefore to determine with accuracy the resistivity of water having salinities of 70, 150, 250, 500, 750 and 1000 grains per gal. The values of resistivity for these salinities were multiplied by the formation factor, which gave the resistivity of a sand characterized by 25 per cent porosity and 100 per cent saturation. The trend of resistivity with saturation was then determined from the curves developed by Martin,[5] Jakosky,[6] Wyckoff,[7] and Leverett,[8] which relate the change in percentage of saturation of a

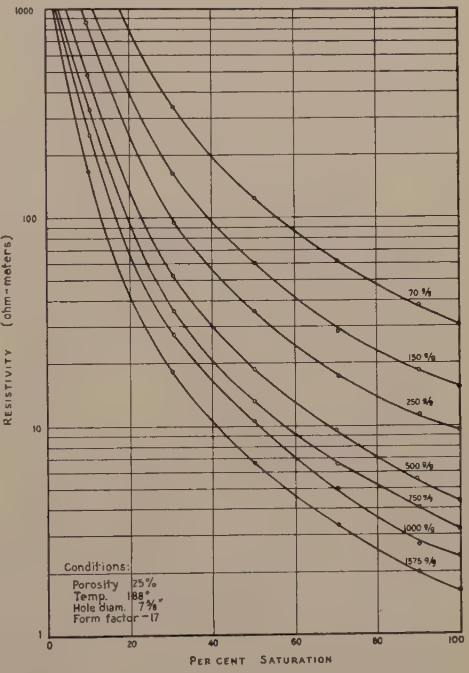

Fig. 11.—Calculated relation between resistivity and percentage of saturation.

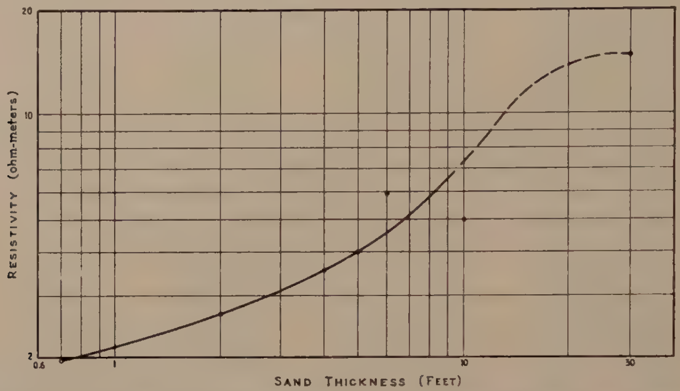

FIG. 12.—RELATION BETWEEN RESISTIVITY AND SAND THICKNESS WHEN SAND PERMEABILITY IS 180 MILLIDARCYS AND ELECTRODE SPACING 63 INCHES.

sand to the percentage of original conductivity at 100 per cent saturation. Before applying the curves in Fig. 11 to the measured values of resistivity, it was necessary to devise an empirical curve that would correct the resistivity for thin sand bodies. A tentative curve was constructed for an average permeability of 180 md. and an electrode spacing of 63 in. (Fig. 12). Because the data were incomplete, the curve has regions of approximation, but for the thinner sand bodies individual points are weighted values and line up on a smooth trend. A curve of thickness factor (Fig. 13) was constructed from Fig. 12.

It is assumed in this construction that the resistivity of the 30-ft. sand is correct and that thickness factors were determined for the thinner sands, so the product of the measured resistivity times the thickness factor equals the true resistivity of the sand. It is believed that the curve for thickness factor can be applied to sands of different permeability with reasonable accuracy. A trial solution was made for a number of cored sands for which the values of permeability were measured (Table 3). Calculations for saturations in Table 3 use the measured resistivity at a penetration of 9.5 feet.

Individual water saturation can be obtained by inserting the corrected resistivity on the curve for 1575 grains per gal. salinity in Fig. 11. These are the values listed as S_2 in Table 3. In order to weight the saturation values for the above eight sands, it was necessary to consider the influence of permeability and sand thickness. The weighted interstitial saturation was determined by taking the sum of the products of sand thickness times permeability times saturation and dividing

TABLE 3.—*Calculated Saturation of Eight Sands*

Sand Thickness t, Ft.	Permeability K, Md.	Critical Saturation S_1, Per Cent	Measured Resistivity 9.5 Ft. D. P.	Thickness Factor, T. F.	Corrected Resistivity, Ohms per Meter	Calculated Saturation S_2, Per Cent
30	180	24	14.6	1	14.6	34
7	977	21	14.35	2.8	40.2	20
5	173	24	4.0	3.6	14.4	34
6	131	26	4.66	3.15	14.7	33
6	91	27	1.8	3.15	5.66	54
7	63	29	5.34	2.8	15.0	33
10	263	23	5.06	2.06	10.4	40
9	57	30	4.0	2.26	9.1	43
	18,021	4,182				5,473

$$\text{Interstitial water} = \frac{4182}{18021} = 23.2 \text{ per cent}$$

$$\text{Calculated saturation} = \frac{5473}{18021} = 30.3 \text{ per cent}$$

Initial cut of well = 37 per cent

by the sum of the products of thickness times permeability. A similar calculation was made for the resistivity saturation S_2.

CONCLUSION

The results of the tests present a relative term depth of penetration for comparing the respective amounts of the formation measured for changes in electrode spacing. By means of this term it becomes possible to construct a resistivity-penetration curve that can be divided into two regions of analysis. First, the portion of the resistivity curve that is affected by the presence of drilling fluid, and second, the value of resistivity measured beyond the influence of the drilling fluid. Correlation for infiltrated portion of the sand represents resistivity as a function of permeability at a constant sand thickness. The cross plot of these data illustrates the very large effect sand thickness has on the measured resistivity. Therefore, it is possible for a thick sand body of low permeability to record a higher resistivity than a thin sand of high permeability.

In the analysis of the second portion of the resistivity curve, calculations are made for the percentage of water saturation by choosing values of resistivity measured beyond the effect of mud infiltration. To do this it was necessary to construct a curve relating sand resistivity to the percentage of saturation. For the thinner sands, a thickness-factor curve aided in correcting the measured resistivity for sand thickness. Calculations were then made on eight sands cored in the well, which differ in thickness and permeability.

After weighting the saturations for thickness and permeability, it was seen that the calculated saturation is greater than the critical saturation. This would suggest that these sands would initially produce some water.

ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to Mr. Howard C. Pyle for directing the work, and to Messrs. John E. Sherborne and Stewart Hagestad, of the Union Oil Company of California, and John C. Stick, Jr., of the Lane Wells Corporation, for their generous help in performing the tests; also to the Union Oil Company of California for its release of the data presented.

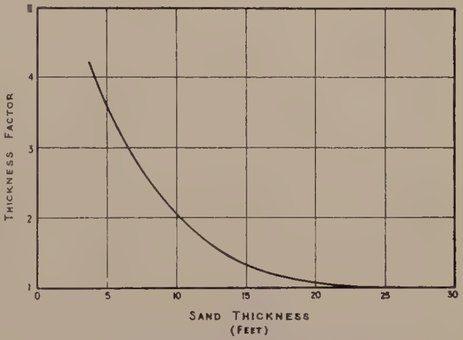

FIG. 13.—RELATION BETWEEN THICKNESS FACTOR AND SAND THICKNESS.

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DISCUSSION

(J. E. Sherborne presiding)

J. C. STICK, JR.,* Los Angeles, Calif.—It is generally recognized that there is a great deal more information contained in electrical logs than is utilized in their normal use. This has resulted primarily from the lack of available data on the behavior of the several variables incorporated in the electrical measurements. The complex nature and interdependence of these variables has greatly complicated their study from the standpoint of obtaining quantitative data on the magnitude of their effects.

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* Lane-Wells Company.

The series of experimental runs from which Dr. Zinszer derived his data were made to study the practical aspects of the effects of these variables and to determine as many empirical relationships as possible between the electrical and physical properties of formations. The results of this study appear to substantiate the possibility of deriving useful relationships between the permeability and fluid saturation of formations and their resistivity as indicated on the electrical log.

The establishment of such relationships is dependent not only on their existence but on the accuracy with which the various parameters can be measured and with which correction factors can be determined and applied. The necessity of obtaining the average of the permeability and porosity values for many sands is recognized as a possible source of error even in a well where core analysis is utilized extensively.

The determination and application of thickness factors are very important in analysis of the resistivity response. The effect of electrode spacing on formation response is clearly illustrated by the series of runs at progressively increasing depths of penetration. For example, the three sands indicated on the 5-in. spacing curve between 5875 and 5890 ft. are resolved into two and then into one sand with increasing depths of penetration. The empirical determination of thickness factors requires careful selection not only of strata of equivalent physical characteristics and thickness but of formations that are sufficiently isolated not to be influenced by the presence of others. The use of these factors must be governed by similar considerations.

The utilization of thickness factors is very important in the analysis of the resistivity curve response. The application of these factors requires careful selection. The utilization of thickness factors is very important in the analysis of the resistivity curves. The application of these factors requires careful consideration of the particular strata to determine the effects of surrounding formations. This is especially true of the thinner beds. For example, the three sands indicated on the 5-in. spacing curve between 5875 and 5890 ft. are resolved into two and then into one sand with increasing depths of penetration. The application of thickness factors to such zones may incorporate considerable error.

G. Potapenko, Pasadena, Calif.—Dr. Zinszer assumes the depth of penetration to be represented by the equation

$$D.P. = \frac{2rr'}{r + r'} \qquad [1]$$

where r and r' are the distances between the pick-up electrodes and the power electrode C_1 (Fig. 1).

It could be shown that the depth of penetration depends upon both r and r' only when approximately

$$r' - r \leq \frac{r + r'}{12} \qquad [2]$$

When this condition is not fulfilled, the potential at the distance r' from C_1 is negligible compared with the potential at the distance r. In such case, the depth of penetration is independent of r', and it may be taken to be approximately equal to r. The data of Table 1 show that in all cases with which Dr. Zinszer deals

$$r' - r \gg \frac{r + r'}{12} \qquad [3]$$

Therefore, Eq. 1, which he uses to calculate the depth of penetration, is inapplicable to his cases, and the curves of Figs. 3 and 4 should be replotted taking r as abscissa. Eq. 1 at $r' \gg r$ goes over into $D.P. = 2r$. Therefore, the suggested change of scale is approximately equivalent to dividing by 2 the depth values indicated in Table 1 and on Figs. 3 and 4.

It is well known that the resistivities calculated from logging data depend upon the ratio of the electrode spacing to the diameter of the hole, especially when this ratio is small, as with 5-in. spacing. Because of this a curve such as is shown in Fig. 13 should be taken to be valid for the given hole diameter only, and it would be of great interest if the thickness factors could be determined for holes of various diameters.

The Effect of Casing Perforations on Well Productivity

By Morris Muskat,* Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

Analytical calculations have been carried out on the effect of casing perforations on the productivity of wells, and formulas have been derived for general types of perforation patterns. The numerical calculations, however, show that the resultant well productivity is essentially independent of the perforation pattern, but is determined mainly by the total perforation density. Thus, for example, for a density of three perforations per foot of casing, the well productivity will be cut to one third of that of the uncased well for a perforation radius of ⅛ in., and to approximately one half for a perforation radius of ¼ in., regardless of the detailed manner in which the perforations are distributed over the casing surface. The analytical theory is also extended to include wells completed with slotted liners. It is shown that the reduction in productivity due to such liners will be relatively small as compared with that due to perforated casings.

Introduction

The increasingly important role being played by productivity factors of wells in determining well potentials and in the general evaluation of producing formations lends interest to the analysis of all the various factors that may influence the productivity of a well. In recent papers[1] the results have been given of theoretical studies made to determine the effect on the productivity factor of a well of the gas-oil ratio of the production and the connate water within the sand. These have served to show that both of these factors may, under suitable conditions, materially reduce the effective productivity factors below those that would be anticipated on the assumption that the wells produce homogeneous fluids.

In this paper will be presented the results of the analysis of an entirely different factor influencing the productivity of a well. This refers to that resulting from the increased use of the method of completing wells by setting casing opposite all of the productive strata and then gun-perforating the particular zones of immediate interest. The practical success of this method of completion would appear to be an answer to the question as to whether it seriously reduces the well productivity or materially cuts down the ultimate oil recovery that may be derived from the producing section. Nevertheless, it is of interest to examine just how great the effect of the restricted flow channels, represented by the gun perforations, may be in increasing the over-all effective sand resistance. Of course, to the extent that the well potentials are severely restricted by proration regulations, minor reductions in well productivities are even less serious than if the wells were to be allowed to produce wide open. On the other hand, even under these circumstances there may be at least the academic interest in such calculations in being able to correct and evaluate the effect of the perforations in order to carry

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* Gulf Research and Development Co. Pittsburgh, Pa.

[1] H. H. Evinger and M. Muskat: Calculation of Productivity Factors for Oil-gas-water Systems in the Steady State. *Trans.* A.I.M.E. (1942) **146**, 126–138, 194–203.

out quantitative comparisons between the observed productivity factors and those that might be predicted on the basis of core analyses.

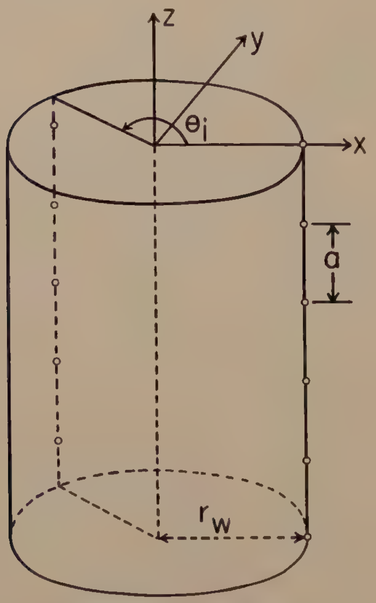

FIG. 1.—DIAGRAMMATIC REPRESENTATION OF A SPIRAL PERFORATION PATTERN.

ANALYTICAL THEORY

In the following analysis, the three-dimensional character of the flow into a well whose only ultimate outlets to the well bore are the casing perforations will be fully taken into account. Nevertheless, it will considerably simplify the computations to suppose that the perforations uniformly extend over the whole thickness of the producing section, and that, in fact, the bounding planes of the producing section form planes of symmetry with respect to the perforations. On the basis of this assumption, we may take the producing zone to be of indefinite thickness, and consider the perforations to lie along indefinitely extended lines covering the whole section, and then ultimately express the results in terms of unit sand thickness. Moreover, to investigate general types of perforation patterns, even though they are not commonly employed in practice, we shall present the general theory for a staggered or spiral system of perforations with an arbitrary number of perforations per pitch of the spiral. Such a pattern may be diagrammatically represented as in Fig. 1, where θ_i represents the angle to the ith line of perforations, as measured from the base line passing through the x axis. The basic spiral or casing radius will be denoted by r_w, which will also equal the well radius. The common radius of the perforations will be denoted by r_p. The x,y coordinates of the perforations on the ith line will be indicated by (x_i,y_i). The spacing between the perforations along each line will be denoted by a.

The analysis will be carried through for homogeneous fluid systems. The heterogeneous character of the flow in wells producing both gas and oil will decrease somewhat the effect of the perforations in reducing the well productivity. However, the labor of solving the flow problem for the multiphase systems would be so great as to be unwarranted merely on the basis of the increased accuracy of the numerical results.

To obtain the productivity of a producing section with a system of perforations like that described, we shall first determine, at least formally, the pressure distribution throughout the system. This will be constructed of a series of basic terms, each representing the contribution of a single perforation line. The latter will be represented analytically as an infinite linear vertical column of sinks situated at (x_i,y_i) with a sink (or perforation) spacing of a. Each such pressure-distribution term, as well as the composite sum, will be a solution of La Place's equation. This representation does not explicitly take into account the fact that the sinks are embedded in an impervious surface, the casing. However, as will be shown in the Appendix, the mutual interference between the various sinks representing the perforations effectively prevents flow between the sinks as if the region between them were actually impermeable.

The pressure distribution for a system of m perforations per pitch may, therefore, be formally expressed as:

$$p = \sum_{0}^{m-1} p_i \qquad [1]$$

where

$$p_i = \frac{-4q}{a}\Big[2\sum_{n} K_o(2n\pi\rho_i) \cos 2n\pi\left(w - \frac{i}{m}\right) + \log 2/\rho_i\Big] \qquad [2]$$

where

$$\left.\begin{aligned} \rho_i^2 &= \frac{(x-x_i)^2 + (y-y_i)^2}{a^2}; \quad w = z/a \\ y_i/x_i &= \tan\theta_i;\ x_i^2 + y_i^2 = r_w^2; \quad \rho_w = r_w/a \end{aligned}\right\} \qquad [3]$$

and K_o is the zero order Hankel function. This expression is that previously developed in the general analysis of three-dimensional homogeneous flow systems.[2] The factor q represents the flux strength of each sink corresponding to a perforation, and ultimately will be eliminated from the calculation of the well productivity.

The value of the pressure given by Eqs. 1 and 2 at points distant from the well, and in particular at a large radius r_e, representing the reservoir radius, is

$$p_e = -\frac{4mq}{a}\log\frac{2}{\rho_e} \qquad [4]$$

where ρ_e has been substituted for $\frac{r_e}{a}$. Eq. 4 represents an approximation in which the series term, which decreases exponentially with the radial distance, has been dropped as compared with the logarithmic term. To this approximation the contribution to the effective reservoir pressure will be the same for each perforation line, and also will be essentially independent of the vertical coordinate.

Since by symmetry all the individual perforations are identical, the well pressure may be determined by focusing the attention upon just one of the perforations; namely, that along the zero line lying on the x axis. For the pressure contribution at this perforation, due to its own line, we must take $\rho_o = \rho_p = \frac{r_p}{a}$. For the contributions due to the other perforation lines, the appropriate value of ρ_i may be readily shown to be given by

$$\rho_i = 2\rho_w \sin\frac{\theta_i}{2} \qquad [5]$$

The resultant well pressure due to the whole perforation system will, therefore, become

$$\left.\begin{aligned} p_w = \frac{-4q}{a}\Big[&2\sum K_o(2n\pi\rho_p) \\ &+ 2\sum(i)\sum(n)K_o\left(4n\pi\rho_w\sin\frac{\theta_i}{2}\right)\cos\frac{2n\pi i}{m} \\ &+ \log 2/\rho_p - (m-1)\log\rho_w \\ &- \sum_{1}^{m-1}\log\sin\frac{\theta_i}{2}\Big] \end{aligned}\right\} \qquad [6]$$

The resultant pressure differential, therefore, will be:

$$\left.\begin{aligned} p_e - p_w = \Delta_p = \frac{4q}{a}\Big[&2\sum K_o(2n\pi\rho_p) \\ &+ 2\sum_{1}^{m-1}(i)\sum_{1}(n)K_o\left(4n\pi\rho_w\sin\frac{\theta_i}{2}\right)\cos\frac{2n\pi i}{m} \\ &+ \log\frac{\rho_e}{\rho_p} + (m-1)\log\frac{\rho_e}{2\rho_w} \\ &- \sum_{1}^{m-1}\log\sin\frac{\theta_i}{2}\Big] \end{aligned}\right\} \qquad [7]$$

Now the total flux through the system per unit sand thickness will be given by:

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[2] Cf. M. Muskat: Flow of Homogeneous Fluids through Porous Media. New York, 1937. McGraw-Hill Book Co.

$$Q = 2\pi \frac{k}{\mu}\left(\frac{r\partial p}{\partial r}\right)_{r_e} = \frac{8\pi mqk}{a\mu} \qquad [8]$$

Eliminating q between Eqs. 7 and 8, we find:

$$\left.\begin{aligned} Q = \frac{2\pi mk\Delta p}{\mu}\Bigg[& 2\sum K_o(2n\pi\rho_p) \\ & + 2\sum_i\sum_n K_o\left(4n\pi\rho_w \sin\frac{\theta_i}{2}\right) \cos\frac{2n\pi i}{m} \\ & + \log\frac{\rho_e}{\rho_p} + (m-1)\log\frac{\rho_e}{2\rho_w} \\ & - \sum \log \sin\frac{\theta_i}{2}\Bigg]^{-1} \end{aligned}\right\} \qquad [9]$$

Introducing now the notation defined by:

$$\left.\begin{aligned} mC = {} & 2\sum K_o(2n\pi\rho_p) \\ & + 2\sum\sum K_o\left(4n\pi\rho_w \sin\frac{\theta_i}{2}\right) \cos\frac{2n\pi i}{m} + \log\frac{\rho_w}{\rho_p} \\ & - \sum \log 2\sin\frac{\theta_i}{2} \end{aligned}\right\} \qquad [10]$$

Q can be expressed by:

$$Q = \frac{2\pi k\Delta p/\mu}{C + \log\dfrac{\rho_e}{\rho_w}} \qquad [11]$$

Recalling now the well-known radial flow formula giving the flux or production rate from an uncased well:

$$Q_o = \frac{2\pi k\Delta p/\mu}{\log\dfrac{\rho_e}{\rho_w}} \qquad [12]$$

we finally obtain for the ratio of the productivity of the cased and perforated well to that of the uncased well

$$\frac{Q}{Q_o} = \frac{\log \rho_e/\rho_w}{C + \log \rho_e/\rho_w} \qquad [13]$$

This is our final equation giving the relative theoretical productivity factor for the cased and perforated well. The reduction in productivity due to the casing and perforations is represented by the constant C, for if the latter be 0, $\frac{Q}{Q_o}$ equals unity and the effect of the perforations vanishes. The numerical problem of evaluating the effect of the perforations thus reduces to that of determining the magnitude of C as a function of the perforation system.

A check upon the form of Eq. 11, and in particular the value of C given by Eq. 10, is provided by the limiting case when a approaches 0. In this case the perforations along each of the several lines merge and the system becomes two-dimensional, corresponding to a battery of wells of radius r_p, distributed uniformly along the circumference of a circle of radius r_w. Since the Hankel function series of Eq. 10 vanishes as a approaches 0, the value for C reduces to the form given by

$$mC = \log\frac{r_w}{r_p} - \sum \log 2\sin\frac{\theta_i}{2} \qquad [14]$$

As it should, this expression agrees with that previously derived for the corresponding problem of a battery of wells in a two-dimensional system (ref. 2).

For numerical purposes it is convenient to write out the values for C for the different systems corresponding to different numbers of perforations per pitch or spiral unit, as follows:

$m = 2$

$$\theta_1 = \pi;$$

Perforation lines separated by 180°

$$C = \sum K_o(2n\pi\rho_p) + \sum K_o(4n\pi\rho_w) \cos n\pi + \tfrac{1}{2}\log\frac{\rho_w}{2\rho_p} \qquad [15]$$

$m = 4$

$$\theta_1 = \frac{\pi}{2};\ \theta_2 = \pi;\ \theta_3 = \frac{3\pi}{2};$$

Perforation lines spaced at 90° intervals.

$$\left.\begin{aligned} C = \tfrac{1}{2}\sum K_o(2n\pi\rho_p) \\ + \sum K_o(2\sqrt{2}\,n\pi\rho_w)\cos\frac{n\pi}{2} \\ + \tfrac{1}{2}\sum K_o(4n\pi\rho_w)\cos n\pi \\ + \tfrac{1}{4}\log\frac{\rho_w}{4\rho_p} \end{aligned}\right\} \quad [16]$$

$m = 8$

$$\theta_1 = \frac{\pi}{4};\ \theta_2 = \frac{\pi}{2};\ \theta_3 = \frac{3\pi}{4};\ \theta_4 = \pi;$$
$$\theta_5 = \frac{5\pi}{4};\ \theta_6 = \frac{3\pi}{2};\ \theta_7 = \frac{7\pi}{4};$$

Perforation lines spaced at 45° intervals.

$$\left.\begin{aligned} C = \tfrac{1}{4}\sum K_o(2n\pi\rho_p) \\ + \tfrac{1}{2}\sum K_o(1.5308n\pi\rho_w)\cos\frac{n\pi}{4} \\ + \tfrac{1}{2}\sum K_o(2\sqrt{2}\,n\pi\rho_w)\cos\frac{n\pi}{2} \\ + \tfrac{1}{2}\sum K_o(3.6956n\pi\rho_w)\cos 3\frac{n\pi}{4} \\ + \tfrac{1}{4}\sum K_o(4n\pi\rho_w)\cos n\pi \\ + \tfrac{1}{8}\log\frac{\rho_w}{\rho_p} - 0.2600 \end{aligned}\right\} \quad [17]$$

Because of the small values of ρ_p that will be of practical interest, it is not convenient to sum directly the series of Hankel functions with argument ρ_p. An analytical summation has therefore been used with the following results:

$1/\rho_p$	6	12	24	48	96	192	384
$\Sigma K_o(2n\pi\rho_p)$	0.5383	1.6980	4.3528	10.0065	21.6604	45.3134	92.9671

The series of Hankel functions with arguments involving ρ_w were summed directly, as they converge very rapidly.

The calculations were carried out for well or casing radii of 3 and 6 in.; for perforation radii of ⅛ and ¼ in.; and for perforation spacings a of 1½ in., 3 in., 6 in., 12 in., and a limiting value of 0. The results are plotted in Figs. 3 and 4.

Coplaner Perfection Patterns

If there is no mutual staggering of the perforations in the various lines—i.e., if the perforations in the several lines all lie in parallel planes normal to the axis of the well bore—the analysis can be carried through in exactly the same manner as for the spiral perforation pattern just discussed. The only change introduced by this simplification is that from Eq. 6 down the cosine coefficients in the multiple Hankel function series should be replaced by unity. When this change is made and the computations repeated, it is found that for the perforation spacings a of the range of practical interest there is no significant difference whatever from the results previously derived for the spiral perforation patterns. The numerical differences be-

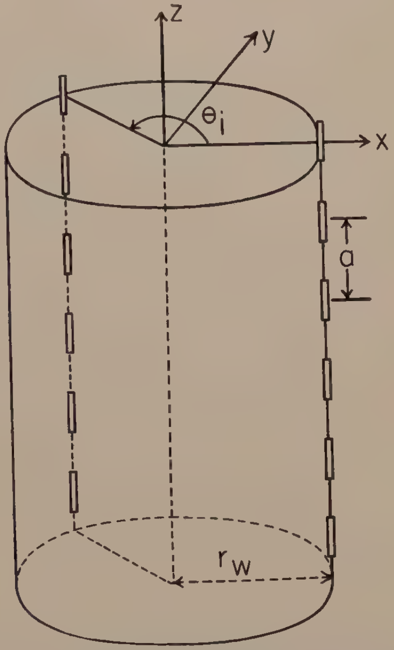

FIG. 2.—DIAGRAMMATIC REPRESENTATION OF A COPLANER SLOTTED-LINER SYSTEM.

come noticeable only for values of a appreciably exceeding 12 in. if the other parameters of the system be kept the same as those used in the consideration of the spiral perforation pattern. It may, therefore, be concluded that the effectiveness of the perforation pattern is independent of the spiral character of the pattern.

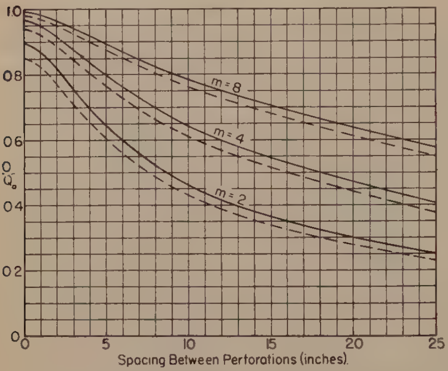

FIG. 3.—EFFECT OF CASING PERFORATIONS ON WELL PRODUCTIVITY.

Q/Q_o = (productive capacity of cased and perforated well)/(production capacity of uncased well).

m = number of perforation lines around casing circumference. For solid curves, casing radius = 3 in.; for dashed curves, casing radius = 6 in.; perforation radius = ¼ in. in all cases.

SLOTTED LINERS*

Thus far we have considered bullet-type perforations, which could be represented mathematically by series of point sinks. By a slight extension of the analysis, however, the treatment can be generalized so as to include slotted liner systems. For simplicity we shall outline here the analysis pertaining only to coplaner slot patterns, such as are diagrammatically shown in Fig. 2. The only basic change that needs to be made in the previous analysis is that instead of the pressure-distribution term describing a perforation line as given by Eq. 2, one must use for a linear system of slots a basic pressure-distribution term given by:

$$p_i = \frac{-4q}{a}\left[2\sum K_o(2n\pi\rho_i)\int_{-h}^{+h}\cos 2n\pi(w-\alpha)d\alpha + 2h\log 2/\rho_i\right] \qquad [18]$$

where the common slot length $2h$ is expressed as a fraction of the mean slot spacing a. Carrying through the rest of the analysis exactly as before, one finally obtains, for the relative productive capacity of the slotted liner system, as compared with that for the uncased sand section, the value given by:

$$\frac{Q}{Q_o} = \frac{\log \rho_e/\rho_w}{C + \log \rho_e/\rho_w} \qquad [19]$$

Here C is defined by:

$$\left.\begin{aligned} mC = {} & 2\sum K_o(2n\pi\rho_p)\frac{\sin 2n\pi h}{2n\pi h} \\ & + 2\sum_i\sum_n K_o\left(4n\pi\rho_w \sin\frac{\theta_i}{2}\right) \\ & \qquad\qquad\qquad \frac{\sin 2n\pi h}{2n\pi h} \\ & + \log\frac{\rho_w}{\rho_p} - \sum \log 2\sin\frac{\theta_i}{2} \end{aligned}\right\} \qquad [20]$$

where the general notation is the same as previously used, and the symbol ρ_p represents now the half width of the slot expressed in units of the mean slot spacing.

Comparison of this value for C with that for the corresponding perforation system as given by Eq. 10, with the cosine terms replaced by unity, shows that the change from perforations to slots is represented by the addition of the factors $\frac{\sin 2n\pi h}{2n\pi h}$ before all the Hankel function terms. As these factors are all less than unity, it is clear that the resultant values of C will be smaller here than in the perforation systems, and hence, as is to be expected, the reduction in productivity factor will be less for the slotted than for the perforated casing. To give an idea of the quantitative magnitude of the difference between a slot and perforation pattern, a specific example was chosen in which the mean slot spacing was 6 in., the slot length 4 in. and slot width ¼ in. It was then found that the relative productive capacity for the slotted liner system, with four columns of slots, would be 88 per cent whereas that for the corresponding perforated casing would be 59 per cent. It thus appears that for all practical purposes a slotted liner may be considered as causing only a negligible reduction in the flow capacity of a producing formation.

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* Model studies of slotted-liner producing systems have been described by F. G. Miller [*Trans.* A.I.M.E. (1941) 142, 137–151]. Unfortunately, however, the results of these investigations are not presented in a form that permits a comparison with those given here.

RESULTS

As already indicated, the basic results of the calculations are shown in Figs. 3 and 4. The ordinates of these figures are the ratios of the productive capacity, or productivity factor, for the cased and perforated wells to those of the equivalent uncased wells. The abscissas are vertical distances, in inches, between the casing perforations along the various lines of perforations. In carrying through the calculations it was assumed that the effective reservoir radius is 660 ft. The curves of Fig. 3 refer to systems in which the perforation radii are ¼ in. The solid curves are those for an effective casing or well radius of 3 in. whereas that for the dashed curve is 6 in. The three pairs of curves are for patterns involving two, four, and eight vertical perforation lines along the casing circumference. It has been further assumed that the various perforation lines are mutually shifted vertically so as to form a composite spiral perforation pattern. (Cf. Fig. 1.)

The curves of Fig. 4 were obtained for exactly the same conditions as those for Fig. 3 except that the perforation radius was taken as ⅛ in. rather than ¼ inch.

Figs. 3 and 4 show that the effect of the perforations may become significant for perforation spacings of the magnitude commonly used in practice. Thus, even for an eight-line pattern of ¼-in. perforations in a 3-in. radius hole, the productivity of the well would be cut to 70 per cent of that for the open hole if the spacing along the lines were as great as 16 inches.

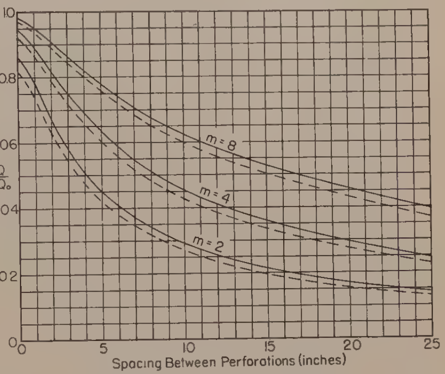


FIG. 4.—EFFECT OF CASING PERFORATIONS ON WELL PRODUCTIVITY.

Q/Q_0 = (productive capacity of cased and perforated well)/production capacity of uncased well).

m = number of perforation lines around casing circumference. For solid curves, casing radius = 3 in.; for dashed curves, casing radius = 6 in.; perforation radius = ⅛ in. in all cases.

As is to be expected, the effect of the perforations in reducing the productivity of the well decreases as the number of lines around the circumference increases, provided the spacing in each line remains fixed. It also decreases as the perforation radius increases. Finally, it is to be noted from Figs. 3 and 4 that the perforation pattern represents a relatively greater part of the resistance to fluid flow in the composite sand and casing system for the wells with larger casing than for those with smaller casing, and hence is of less importance in the latter.

As indicated above, a coplaner or nonspiral perforation pattern has, for all practical purposes, exactly the same effect on the well productivity as the spiral perforation pattern. Moreover, as may be checked by direct references to Figs. 3 and 4, it is essentially the total number of perforations over a given sand thickness that determines the reduction in well productivity. Thus, for example, referring to Fig. 3, a cased 25-ft. section of sand, gun-perforated with 100 bullets distributed along two lines 180° apart, and with a perforation spacing of 6 in., will have a productive capacity 60 per cent that of the uncased section. If the 100 perforations are distributed with a spacing of 12 in. along four lines spaced at 90° intervals around the circumference, it will still have a relative productive capacity of 60 per cent. Finally, if the same 100 perforations were distributed along eight lines, separated by 45° intervals around the circumference, with a spacing within the lines of 24 in., the relative productive capacity would be 59 per cent. If only 50 shots were distributed over the 25-ft. interval, the relative productive capacity would be approximately 41.5 per cent for the three different distributions considered here. For smaller perforation spacings, or greater total number of perforations per unit length of casing, there is some spread in the values of Q/Q_0, depending on the number of perforation lines. However, in the range of practical interest, it is the total number of perforations per unit length of sand section, or of casing, rather than the details of the distribution, that determines the well productivity.

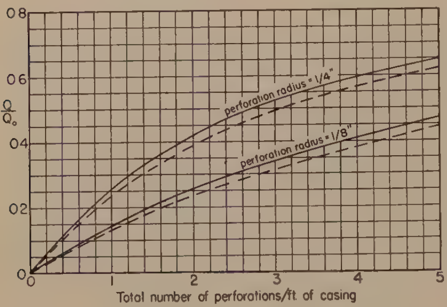


FIG. 5.—EFFECT OF CASING PERFORATIONS ON WELL PRODUCTIVITY AS A FUNCTION OF THE OVER-ALL DENSITY OF PERFORATIONS.

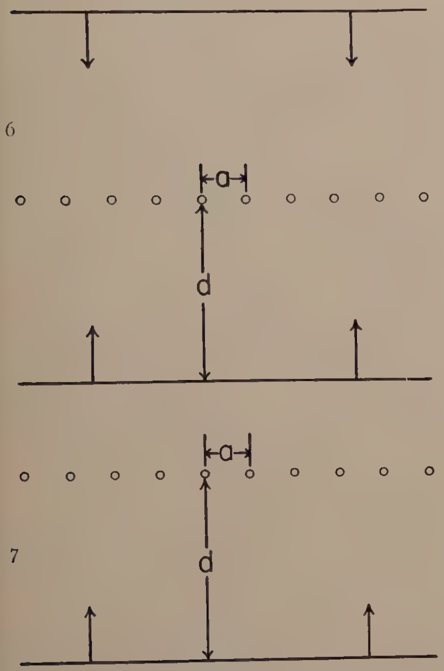
Q/Q_0 = (productive capacity of cased and perforated well)/(production capacity of uncased well).

For solid curves, casing radius = 3 in.; for dashed curves, casing radius = 6 in.

The variation of the relative productive capacity with the over-all perforation density is shown in Fig. 5. The curves of that figure represent essentially a replotting of those of Figs. 3 and 4 together with an averaging over the small variations corresponding to the different perforation distributions. There is a tapering off of the rate of rise of relative productive capacity with perforation density as the latter increases; thus, for a perforation radius of ¼ in. and an effective casing radius of 3 in., the relative productive capacity increases only from 41.9 to 59.4 per cent on doubling the perforation density from 2 to 4 perforations per foot. However, up to perforation densities of one per foot, the relative productive capacity is approximately proportional to the density.

As was also shown previously, the generalization of the problem of a perforated casing to that of a slotted liner indicates that for all practical purposes the latter may be considered as causing but a negligible reduction in the productive capacity of a well. Thus, whereas a 6-in. casing with perforations ¼ in. in diameter spaced at 6 in. along four lines would cut the productive capacity of a well down to 59 per cent of that of a well with an open hole, the relative capacity will be 88 per cent with a 6-in. liner that has four columns of slots of ¼ in. wide, 4 in. long and 6-in. mean vertical spacing.

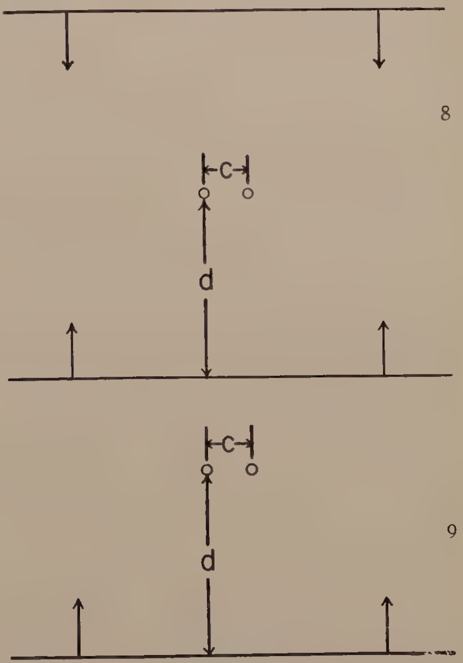
While it is felt that the calculations reported here do indicate correctly the magnitude of the effect of casing perforations on well productivity, it is not to be assumed that the predicted effects will necessarily be observed in field practice. For the actual productivity of a well is the resultant of a great many factors, only one of which is the type of casing perforations, if any. Variations in these other factors—sand permeability, fluid-saturation distribution, gas-oil ratio, cleanliness of sand face, etc.—may well counterbalance and mask completely the limited effect of the casing perforations in making comparisons between cased and open-hole completions even in the same field. The present calculations are based on idealized assumptions and possess no greater validity than these assumptions.



Figs. 6 and 7.—Line drive into infinite line of wells. No flow across line.
Fig. 6. Symmetrical case.
Fig. 7. Unsymmetrical case.

APPENDIX

In addition to the basic assumption made throughout the analysis presented here, that the production section is carrying a homogeneous fluid, there is another of a purely analytical character. This refers to the fact that the mathematical representation of the perforations as point sinks does not of itself provide for the fact that these sinks are located on an impervious surface; namely, the casing. To have included that fact directly into the analysis would have led to almost insurmountable difficulties. On the other hand, it might appear that unless this were actually done the approximation might be so poor as to be of no value. It is, therefore, of interest to note that for systems with dimensions of practical interest no significant error is introduced by not taking into account explicitly the presence of the casing as an impermeable surface in which are embedded the sinks representing the perforations.



Figs. 8 and 9.—Line drive into pair of wells. No flow across line.
Fig. 8. Symmetrical case.
Fig. 9. Unsymmetrical case.

The essence of the argument justifying the use of the method of analysis given here lies in the observation that because of the mutual interference between the multiplicity of perforations comprising the composite network, the latter shields the interior of the casing surface almost completely from inward flow, as if the region between the perforations were actually strictly impermeable. This fact is a consequence of the extremely close spacing of the perforations as compared with the only other physical dimension of interest; namely, the distance of the fluid driving source, i.e., the reservoir radius. It may be demonstrated easily by reference to the equivalent two-dimensional systems. Thus with respect to the vertical shielding—i.e., the prevention of flow between the perforations on the single line—it is appropriate to consider the analogous two-dimensional case of the line drive into an infinite line of wells. In the symmetrical case (Fig. 6), where there is obviously no flow whatever across the line of wells, and where $d/a > 1$, it is easy to show that the flux per well from either side is given by

$$Q = \frac{\pi k \Delta p/\mu}{\log \dfrac{e^{\pi d/a}}{2\pi r_p/a}} \qquad [21]$$

On the other hand, for the unsymmetrical case shown in Fig. 7, which corresponds to the mathematical representation of our casing perforation problem, it may be shown that the flux per well is

$$Q = \frac{2\pi k \Delta p/\mu}{\log \dfrac{e^{2\pi d/a}}{2\pi r_p/a}} \qquad [22]$$

Since d here corresponds to the reservoir radius r_e in the previous problem, and a to the perforation spacing, it is clear that $d/a >> 1$. A comparison of Eqs. 21 and 22 for this condition immediately shows that the two values of Q are then equal for all practical purposes. This, of course, means that the shielding in the unsymmetrical case of Fig. 7 is complete, and that there is no net flow of appreciable magnitude crossing the line of wells. By analogy, therefore, it may be concluded that for the mathematical representation used above there will be no net flow between the perforations along the lines even though this requirement was not introduced explicitly.

Similar considerations can be applied to the problem of fluid shielding between the several lines. Here the two-dimensional analogy to the extreme case of two perforation lines is a line drive into a pair of wells. For the symmetrical case in which the flow across the line connecting the wells is strictly eliminated (cf. Fig. 8), the flux per well may be shown to be:

$$Q = \frac{\pi k \Delta p/\mu}{\log d/\sqrt{c r_p}} \qquad [23]$$

where d corresponds to the external radius r_e, c corresponds to the casing diameter, and r_p represents the equivalent of the perforation radius. On the other hand, for the unsymmetrical case (Fig. 9), the flux per well may be shown to be, for $d/c >> 1$:

$$Q = \frac{\pi k \Delta p/\mu}{\log 2d\sqrt{c r_w}} \qquad [24]$$

It will be clear that here, too, the values of Q as given by Eqs. 23 and 24 are equal for all practical purposes, thus showing that the prevention of flow across the cylindrical surface between the perforations is again automatically taken care of without introducing it directly into the analysis.

DISCUSSION

(*Donald L. Katz presiding*)

S. E. Buckley,* Houston, Texas.—I should like to ask Dr. Muskat whether or not the calculated curves showing the effects of casing perforations on well productivity are applicable to gas wells.

Also, a second question: Many oil and gas sands in the Gulf Coast area are stratified or laminated to such a degree that the effective permeability across the bedding planes is frequently much lower than the permeability along the bedding planes. What would be the effect of the number of casing perforations on well productivity if such variation of permeability were taken into account?

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* Humble Oil and Refining Company.

J. D. Hughes,* Houston, Texas.—The subject of casing-perforation densities is one that has plagued all concerned with this type of completion, and particularly the service companies. We have wrestled mightily with the problem and until this splendid paper had found no fulcrum for our lever; at least we now have such a point of attack, and it remains to be seen how well it is borne out in practice.

In our investigations upon this subject, we conferred with many engineers and operators within the industry and collected theories upon optimum perforation densities ranging from a single ideally placed perforation up to a number whose total area equaled that of the tubing. Somewhere between these extremes is our answer and this will vary with conditions and the objective. For instance, a certain desirable selectivity can be obtained by varying the density with regard to the permeability of the formation opposite to allow a more uniform withdrawal or in reverse a more uniform injection, as with water-disposal, gas-injection, or water-flood wells. As a general rule it has been found far more satisfactory to perforate the input wells with a considerably increased density, usually about double the number used for production. This variation in density with permeability has proved helpful in the even distribution of attack of acid applications to limestone horizons. Another point to remember is the practical necessity of applying a safety factor in the form of a few more holes per foot to take care of those perforations that may become bridged or plugged in the course of time. Our experience has led us to the conclusion that for general production shooting the optimum will fall somewhere in the neighborhood of six holes per foot, and it is interesting to note that Dr. Muskat's curves begin to flatten out in this region. These same curves illustrate that in the past, and in the absence of sound engineering criteria, wells that have been perforated with a density based primarily upon consideration of economy may prove to have a very effective bottom-hole choke when, under the stimulus of demand, it is desired to increase the rate of withdrawal.

It would be extremely helpful to the industry at large if this problem were investigated further, that the mathematical analysis might be subject to the test of field observation. This would of necessity be a cooperative venture and require considerable financial outlay on the part of some company or individual, who would make first an open-hole completion and measure the productivity, following which a liner could be set and the productivity at increasing perforation densities measured. Not having any wells to offer for such an experiment, but to lessen the burden on those who would, I offer in the name of my employer the contribution of the perforations required in a zone of reasonable thickness, to complete such a fundamental project.

D. Silverman,* Tulsa, Okla.—Dr. Muskat's paper raises an interesting point, which I do not think has been sufficiently accentuated. The simplest expression of this relationship is illustrated in Fig. 5, in which the effect on productive capacity is dependent upon the diameter of the perforations, rather than upon their area. This is shown by the fact that the abscissas for the curve of perforation radius equal to ⅛ in. are approximately double those for the curve drawn for radius ¼ in., or the same effect on productive capacity is had by decreasing the radius by a factor of 2 and increasing the number of holes by a corresponding factor. In other words, an increase in mechanical strength of the pipe can be obtained without affecting the productive capacity, by making the holes of smaller radius and increasing their number.

This same effect is illustrated also in Figs. 3 and 4. For example, if the lower curve of Fig. 3, corresponding to $m = 2$, is placed upon Fig. 4, it will coincide with the curve for $m = 4$, indicating that on the basis of radius twice as many perforations per foot are required if the diameter of the holes is cut in half. On the basis of area, however, to provide a pipe of equal strength four times as many holes could be provided, which would correspond to the curve of Fig. 4 for $m = 8$, with a consequent increase in productive capacity.

Of course, in perforating casing the limitation is not so much a matter of area and strength as of the number of perforations. The case is different for a slotted liner, and since the same reasoning can be applied, it may indicate that a greater productive capacity can be obtained by making a perforated liner rather than a slotted liner.

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* Lane-Wells Company.

* Stanolind Oil and Gas Co.

On page 182, Dr. Muskat has given some figures for the productive capacity of a slotted liner, in which four 4-in. slots ¼ in. wide are placed in each 6 in. of pipe length, to provide a ratio of Q/Q_o of 88 per cent. On the basis of area, the total opening would correspond to approximately 8 sq. in. per foot, which would correspond approximately to 160 holes per foot, each ¼ in. in diameter. This would give a productive capacity of about 97 per cent, as compared with 88 per cent for the slots. Conversely, on the basis of 88 per cent productive capacity, the same effect would be obtained by means of 35 to 40 holes of ¼-in. diameter. The area of these holes would be approximately one fourth of the area of the slots, requiring a liner of increased mechanical strength.

M. Muskat (author's reply).—The answer to Mr. Buckley's first question is that the calculated curves are applicable to gas wells. In fact, whereas the assumptions of a homogeneous fluid system and potential flow will be satisfied only approximately for wells producing both oil and gas, they should be strictly valid for wells producing only gas.

Mr. Buckley's second question is indeed pertinent. For it is true that, especially in the Gulf Coast region, strict sand isotropy is the exception rather than the rule. With respect to sand systems in which the vertical is less than the horizontal permeability, the relative productivity for cased and perforated wells will always be less than indicated by the curves of Figs. 3 to 5 for an isotropic sand. A direct solution of the potential-flow problem for an anisotropic sand leads formally to the same solutions given by Eqs. 13 and 10. However, the dimensionless radii ρ_w, ρ_p are now given by:

$$\rho_w = r_w/\alpha a; \qquad \rho_p = r_p/\alpha a$$

where r_w, r_p are the well and perforation radii, a is the vertical spacing between the perforations and $\alpha = \sqrt{k_r/k_z}$ where k_r is the horizontal and k_z the vertical permeability. Moreover, the formal solution now corresponds to a constant pressure perforation cavity, which is a spheroid of semi-axis r_p in the horizontal plane and r_p/α vertically, in contrast with the hemispherical cavity of the isotropic case. The effective equivalent hemispherical perforation radius has therefore been taken as the geometric mean of the two semi-axes. While with this substitution the value of C reduces to the isotropic form for $\alpha = 1$, the term α still persists in the limiting case of $a \rightarrow 0$, where the sand anisotropy should have no effect. Unfortunately this difficulty cannot be obviated in a rigorous manner by any simple procedure and the extraneous term was therefore eliminated by arbitrarily adding to C an appropriate constant, $\frac{1}{2m}\log\alpha$. Thus the form of C as finally used was:

$$mC = 2\sum K_o\left(\frac{2n\pi\rho_p}{\sqrt{\alpha}}\right) + 2\sum\sum K_o\left(\frac{4n\pi\rho_w}{\alpha}\sin\frac{\theta_i}{2}\right) + \log\frac{\rho_w}{\rho_p} - \sum \log 2\sin\frac{\theta_i}{2},$$

for the unstaggered perforation system of m lines with ρ_p and ρ_w now having the same definition as in Eq. 10. Although this does not represent a strictly accurate formula, in the sense of Eq. 10, it is felt that it should give the effect of the anisotropy with a precision sufficient for practical engineering purposes.

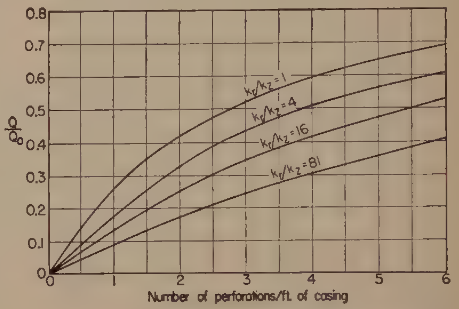

Fig. 10.—Effect of casing perforations on well productivity as function of perforation density in anisotropic sands.

Q/Q_o = (productive capacity of cased and perforated well)/(productive capacity of uncased well). k_r/k_z = (horizontal permeability)/(vertical permeability). Well radius = 3 in.: perforation radius = ¼ in.

Using the expression given above for C, and Eq. 13, Q/Q_0 was calculated for a perforation radius of ¼ in., well radius of 3 in. and anisotropy ratios α^2 of 4, 16 and 81. The results are plotted in Fig. 10, together with the curve for the isotropic case, $k_r/k_z = 1$.

While appreciable, the effect of the anisotropy in further reducing the relative well productivity is not very large. Moreover, equal increments in k_r/k_z have continually diminishing influence on Q/Q_o. The reason for this behavior lies evidently in the fact that throughout the distant parts of the sand the flow is essentially horizontal and the vertical components become important only in the close neighborhood of the casing.

It is pleasing to note that Mr. Hughes has found that this paper has practical application in the operating problems of the service companies. While the calculations of the present paper do indicate that a perforated casing does restrict the fluid flowing to a well, this, of course, does not imply that the advantages of perforated casing do not in general far outweigh the apparent lowering of the well productivity factor, especially in fields subject to proration. It is to be hoped that Mr. Hughes' offer of cooperation with owners of oil wells in making practical tests on the effect of perforation density will be accepted. It is only in this way that laboratory researches can be correlated with practical field experience.

Dr. Silverman's comments are well taken. It is quite true, as he points out, that the relative productivity of wells with perforated casing is essentially a function of the product of the perforation density and perforation radius. Hence, if the data of Figs. 3 to 5 were plotted as a function of this product, the curves for different perforation radius would practically coincide. This result is of course a consequence of the analytical formulas, in particular Eqs. 10, 15, 16 and 17. These show that the constant C is essentially determined by the value of ρ_p and varies but slowly with ρ_w. ρ_p, on the other hand, is the ratio of the perforation radius to the perforation spacing a, which in turn is inversely proportional to the perforation density. The physical reason for this situation is that the ratio of perforation radius to spacing is physically the primary parameter determining the degree of flow convergence involved in the passage of the fluid from the distant parts of the pay, where the flow is essentially radial, to the well bore where it has to converge so as to enter the individual perforations.

Dr. Silverman's practical comments are also very pertinent. There can be no doubt, as he suggests, that the strength of the perforated casing will be greater if smaller size perforations are used, even though the density has to be proportionately increased to give the same productivity. Although the plugging difficulties may be more serious when the smaller holes are used, the increased pipe strength will probably be a more significant factor under most conditions, and especially those where the producing formation is not competent and the casing has to withstand the full burden of preventing complete collapse of the hole.

Asphaltic Substances in Crude Oils

By G. W. Preckshot,* N. G. DeLisle,† C. E. Cottrell† and D. L. Katz,† Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

Most crude oils contain asphaltic substances that may be naturally or artificially precipitated. In the Greeley field, California, this asphaltic bitumen is precipitated during the flow of the oil from the reservoir to the stock tank. The mechanism of such precipitation is not well understood. This paper presents the progress that has been made by using the electron microscope as a new tool and by observing the effects of the streaming potential on the formation of bitumen particles.

Crude oils at atmospheric pressure viewed in the electron microscope in very thin films under a vacuum showed no asphaltic particles. A technique of preparing slides of thin films by dilution of the oil with benzene and washing in petroleum ether was used at first, and these observations showed that the solvents caused the formation of the particles, varying from 0.01 to 0.2 micron in diameter.

The electrical effects of fluids flowing through porous solid were studied, with emphasis on the formation of colloidal particles by the streaming potential. The streaming potential of crude oil flowing through sand was measured and was shown to be responsible for the formation of bitumen particles. These results bring out a new phenomenon, which may occur when crude oil flows through the porous oil reservoir.

I. The Electron Microscope as a New Tool

By N. G. DeLisle, C. E. Cottrell and D. L. Katz

Asphaltic particles have been precipitated from crude oils by a variety of mechanisms. Asphalt has been the subject of widespread investigation but, owing to the complexity of the substances being considered, progress has been slow. Investigators working primarily with the asphaltic substances have treated the subject from the colloidal standpoint and have developed theories that picture the asphaltic particles as surrounded by adsorbed materials.[14,15,17,24] The deasphaltization of lubricating oil by the use of solvents treats the subject primarily from the standpoint of liquid-liquid equilibria.[10] A complete understanding of asphaltic substances would make possible the following of the material from its initial state in the crude oil through precipitation processes to the final plastic stage, the most common form of which is used in asphaltic pavements.

Since these asphaltic particles are very small, it appears that the electron microscope[4] might be a useful tool in studying the precipitation processes. Specimens are examined by the electron microscope in a vacuum and as very thin films, requiring special techniques in preparation of samples. A brief description of the electron microscope and its operation will bring out the difficulties and advantages of its use for this problem.

The first work was done with crude oils that had been diluted with solvents for the preparation of the film to be examined. Later a technique was developed by which the undiluted oil film could be made thin enough for direct examination. These two techniques show vastly different results

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* Standard Oil Company of California Fellow, University of Michigan 1940–42.

† University of Michigan, Ann Arbor, Mich.

[14] References are at the end of the paper.

and have added to our knowledge of the precipitation of asphaltic substances.

The Electron Microscope

The electron microscope was purchased from the Radio Corporation of America by a grant from the Horace H. Rackham School of Graduate Studies. The instrument was installed in the spring of 1941 in the physics department at the University of Michigan, under the supervision of Prof. O. S. Duffendack. Dr. L. Marton assisted in developing the initial technique with the instrument. Mr. R. G. Picard operated the instrument for the earlier work and later Mr. Picard and Mr. T. R. Kohler made the observations with the instrument. The Department of Engineering Research of the University of Michigan contributed funds for the preparation of the samples in the earlier part of the work.

Principles of construction of the electron microscope are similar to those of the compound optical microscope. Fig. 1 is a diagrammatic sketch of the essential operating parts of the instrument. The object is placed in the system, which is maintained at a pressure less than 10^{-4} mm. of mercury, to permit free movement of the electrons. The electrons are emitted from a hot cathode and their paths are controlled by magnetic lenses.

The electrons that encounter a bitumen particle are deflected from the beam. The remainder of the electrons strike a fluorescent screen. The deflected electrons cause discontinuities in the beam, which are observed as spots on the screen, showing the profile of the particle.

Continuous visual observations may be made at low and at high magnifications. The low magnification is used to locate a suitable area for observation. The high magnifications range from 1200 to 23,000 diameters. Photographs may be made at these magnifications. Usual photographic enlargements of these negatives give photographs with magnifications as high as 150,000 diameters.

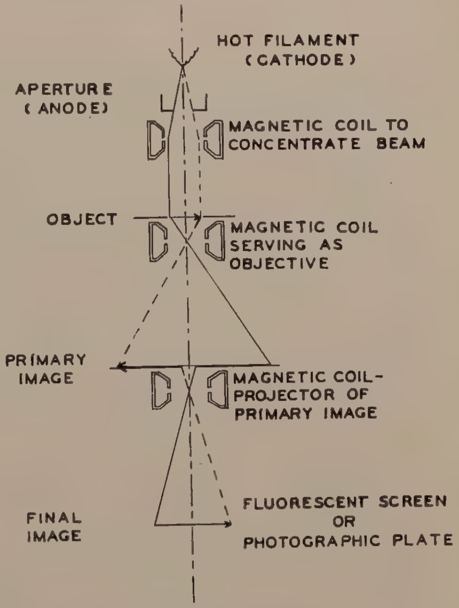
HOT FILAMENT (CATHODE)
APERTURE (ANODE)
MAGNETIC COIL TO CONCENTRATE BEAM
OBJECT
MAGNETIC COIL SERVING AS OBJECTIVE
PRIMARY IMAGE
MAGNETIC COIL-PROJECTOR OF PRIMARY IMAGE
FINAL IMAGE
FLUORESCENT SCREEN OR PHOTOGRAPHIC PLATE

Fig. 1.—Diagrammatic sketch of electron microscope.

Preparation of Samples

Samples used for examination are extremely small. The most satisfactory technique has been to place the sample upon a collodion film supported by a 200-mesh stainless-steel gauze ⅛ in. in diameter. The collodion film is formed by spreading a drop of its amyl acetate solution on water and allowing the solvent to evaporate. After the gauze has been dropped upon this collodion film, the film and screen are lifted from the water solution and allowed to dry. This method was suggested by Dr. L. Marton. The collodion film does not obstruct the path of the electrons, although it may rupture because of desiccation and the bombardment from the electrons and must be treated with exceeding care.

There are two techniques for placing the sample of oil upon the collodion to prepare the slide. The first method is to place a small drop of diluted oil directly upon the collodion film by means of a tiny pipette. This oil must be diluted with some solvent to make the film extremely thin. Benzene was used for the solvent in most of the experiments in this work. The other method is to place the oil upon the surface of water in a container and after the oil has spread to a very thin film on the water to drop upon it the gauze with adhering collodion film. The removal of the gauze and adhering collodion film completes the preparation of the slide, because the oil layer adheres to the collodion film. This method made it possible to obtain a very thin film of oil without dilution. After preparation, the samples are allowed to stand at room conditions, protected from dust, to permit evaporation of the water and volatile materials. Further evaporation takes place when the specimen is introduced into the microscope at the lower pressure of 10^{-4} mm. of mercury. Some difficulties were experienced from the evaporation and subsequent precipitation or condensation of an oil film on various portions of the instrument.

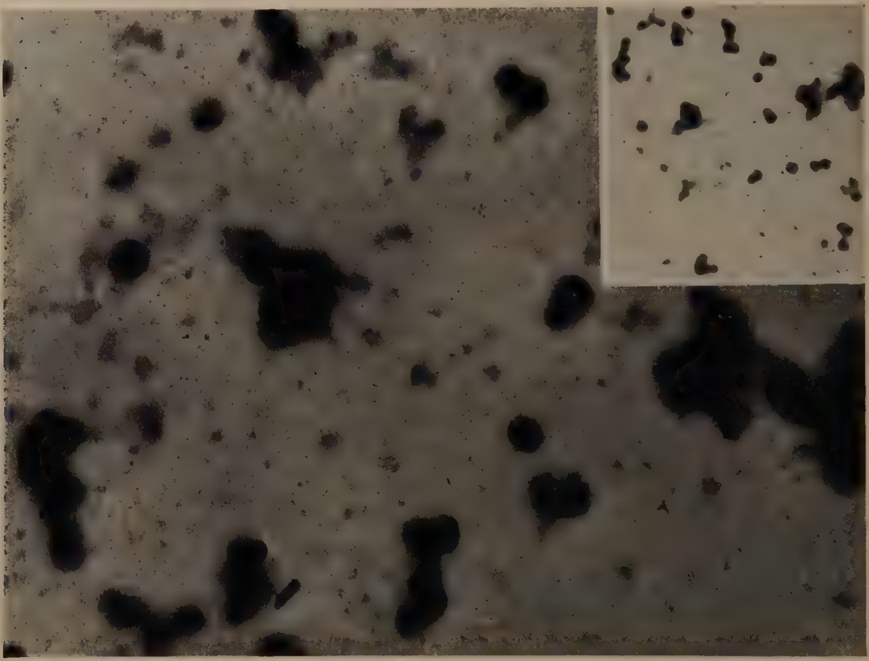

FIG. 2.—CALIFORNIA CRUDE BITUMEN FROM BENZENE SOLUTION (54-1). 9300 and 37,200 diameters.

OBSERVATIONS OF OILS TREATED WITH SOLVENTS

The first experiment was the observation of a specimen of bitumen that had been dissolved in benzene and placed on the collodion film. This bitumen was precipitated from Greeley crude oil in California; it was found in both the tubing and the oil-gas separator of certain flowing oil wells. When dried it has the appearance of asphalt. Fig. 2 is the electron photomicrograph of this specimen at 9300 and at 37,200 diameters. The particles are essentially spherical and tend to cluster. Individual particles range from 0.01 to 0.15 microns in diameter.

The first observations on Greeley crude oil diluted with benzene encountered difficulty in obtaining sharp images. Fig. 3 gives 9300 and 37,200-diameter photographs of the specimen when made by making a hundred to one dilution of the crude oil in benzene. The opinion of Dr. Marton[13] at this stage was that the shaded area surrounding the dark spots represented oil that was physically held to the particle. The question arose of methods by which this oil might be removed, and a technique of washing the film by dipping the slide into petroleum ether was devised. This procedure appeared to remove the shaded area around the particle and gave electron photomicrographs as shown in Figs. 4 and 5.

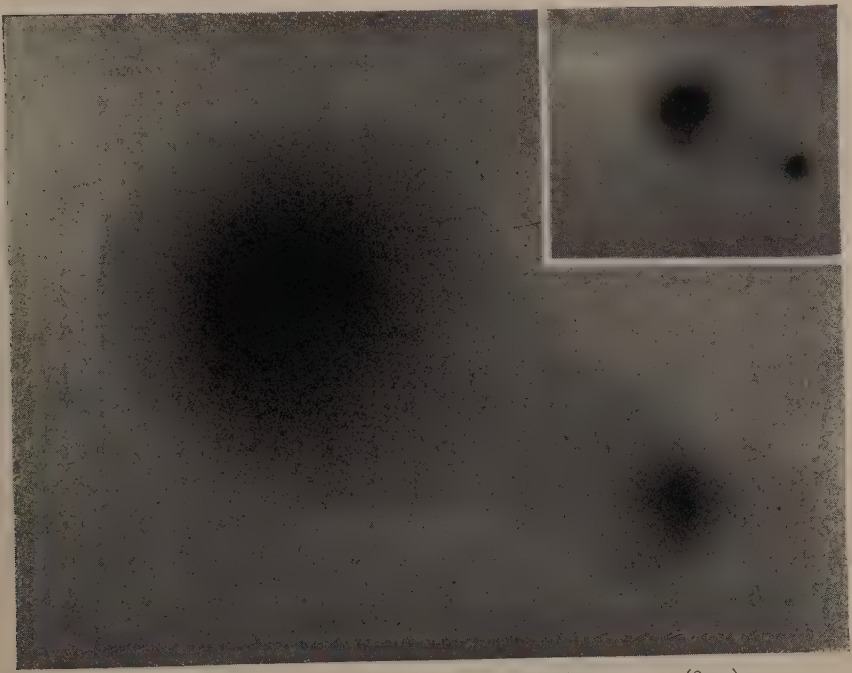

Fig. 3.—California crude oil from benzene solution (85-3). 9300 and 37,200 diameters.

Similar studies were made on a variety of crude oils. Fig. 6 shows the asphaltic particles in 24.4°A.P.I. Kansas crude oil[23] after dilution with benzene and dipping in petroleum ether. This crude contained a considerable quantity of asphaltic constituents, which, when separated from the crude oil, are very similar in appearance to the bitumen from Greeley crude oil. Fig. 7 gives photographs of crude oil from East Texas and from Billings, Okla.; a sample of Oklahoma City Wilcox crude and the 32.6°A.P.I. Arkansas crude.[23] The pictures are not sharp because of difficulty in focusing, but definitely establish the presence of particles. Later in this work it was discovered that the collodion film and the screen were contaminated by particles. A study of a series of blanks indicated that dust-free collodion films on new screens gave slides showing from zero to about five particles per mesh. It should be noted that the area of one mesh enlarged 9300 times gives an area of 730 sq. in. (27 × 27). The investigation of the blanks gave experience in distinguishing between contamination and the particles present in a specimen. The particles shown on Fig. 7, with few exceptions, are believed to be from the crude oils.

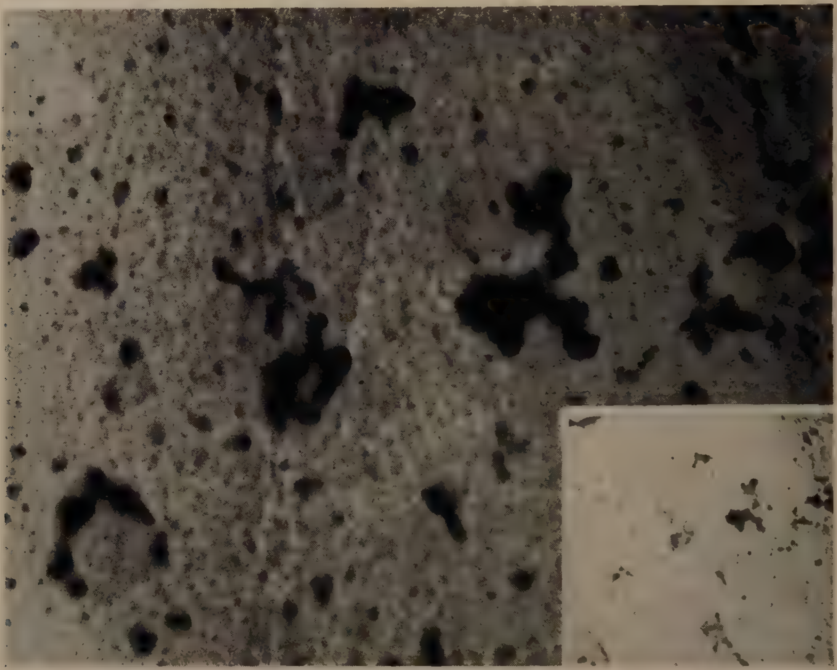

Fig. 4.—California crude oil diluted with benzene and washed with petroleum ether (106-1).
9300 and 37,200 diameters.

For comparison, slides were prepared from the bottoms of a distillation of a cracked product and from the last cut over on the laboratory fractionating column. Fig. 8 is a slide of the residue from a cracked recycle stock that had been diluted with benzene and washed in petroleum ether; Fig. 9 is that for the last fraction taken overhead in a vacuum distillation of this recycle stock. The similarity between the particles of these slides and those previously given is very striking.

A later development in the preparation of the slide was to place the undiluted oil directly upon the collodion film, but it was necessary to dip this sample into petroleum ether before the specimen could be observed. Fig. 10 was taken on the California oil prepared in this manner.

Previous information and laboratory experiments in diluting these oils with solvents indicated that the solvent could cause precipitation of asphaltic substances. The dilution of the sample with a solvent or the dipping of the slide into the petroleum ether could have caused the particles to appear and the photographs shown do not necessarily prove that these particles were present in the original oils. The technique of spreading oil upon water to make very thin films for examination made it possible to examine the undiluted and unwashed oils.

Photographs of Undiluted and Unwashed Oils

Although the effects of the solvents could be eliminated by preparing a very thin film of the oil and observing the unwashed specimen, the effect of evaporation could not be eliminated. The presence of particles in these specimens would not definitely prove that they were in the original oil, because of the evaporation that takes place. It is believed that the absence of particles in these slides would indicate that they were absent in the original oil or of such a small size that they could not be detected by the electron microscope.

Figs. 11 and 12 are typical photographs of the appearance of the crude oil when prepared by this process. Fig. 12 shows two particles but it is not definitely known that these are asphaltic particles. Although many observations were made and several crudes were observed, the other pictures show no more than Fig. 11. A few particles as shown in Fig. 12 were occasionally found, but the frequency of their occurrence was little more than could be expected from the contamination of the collodion film. In general, this would indicate that the original oil under a pressure of less than 10^{-4} mm. of mercury did not contain asphaltic particles, although the diluted and washed sample definitely indicated that particles were present in the specimen. It follows that the particles were precipitated by the method of preparing the slide.

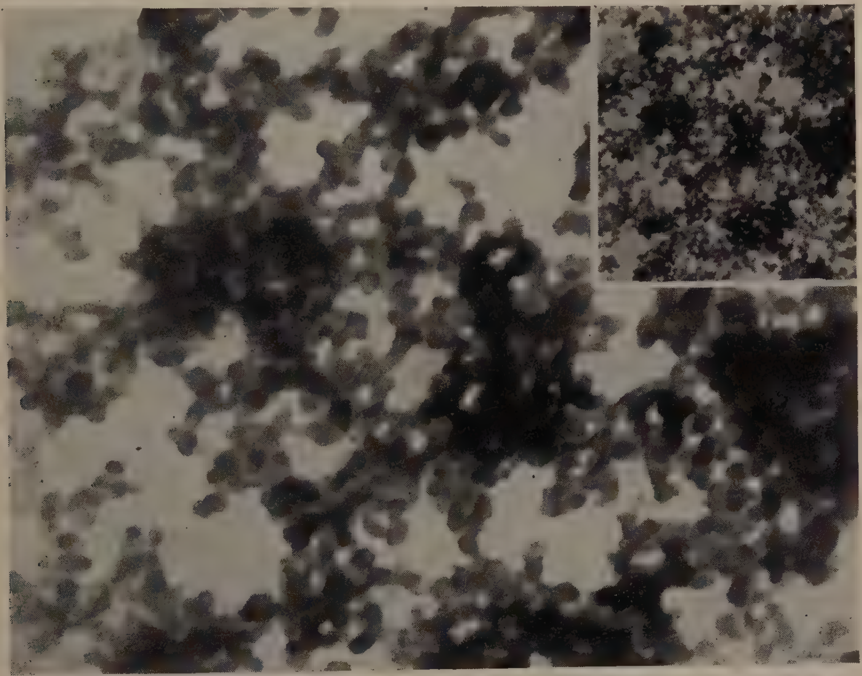

FIG. 5.—CALIFORNIA CRUDE OIL DILUTED WITH BENZENE AND WASHED WITH PETROLEUM ETHER (299-5).
9300 and 37,200 diameters.

Effect of Solvents

The effects of benzene and petroleum ether upon the precipitation of the bitumen or asphaltic constituents is in accord with the general information available on

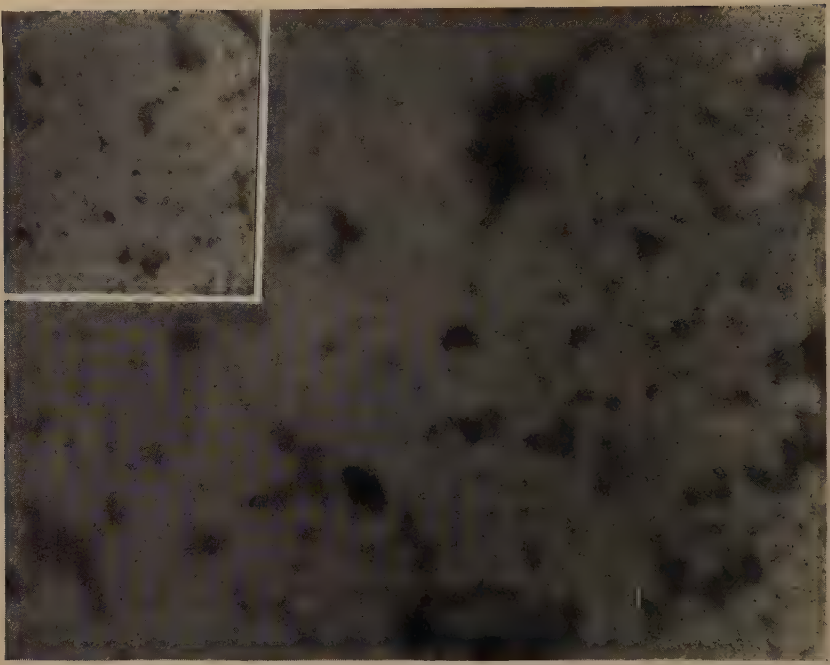

Fig. 6.—24.4°A.P.I. Kansas Dopita crude diluted with benzene and washed with petroleum ether (107-2).
14,600 and 58,400 diameters.

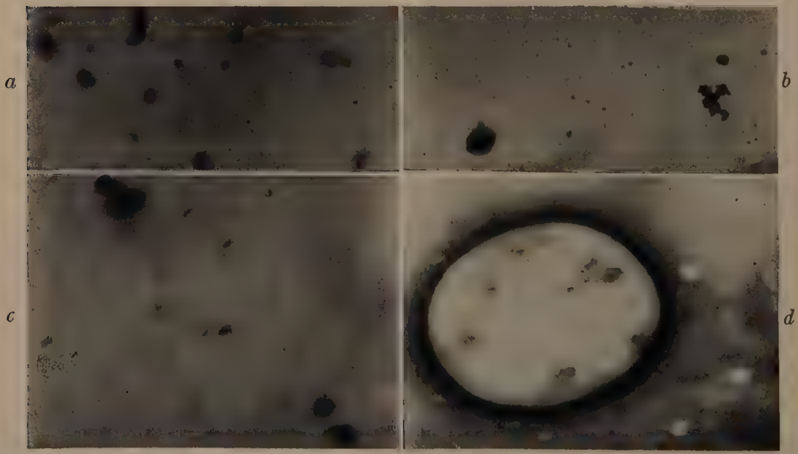

Fig. 7.—Crude oils diluted with benzene and washed with petroleum ether.
a. East Texas Woodbine (110-1). 14,600 diameters.
b. Oklahoma City Wilcox (106-5). 14,600 diameters.
c. Billings Oklahoma Wilcox (86-4). 9300 diameters.
d. Arkansas (103-1). 14,600 diameters.

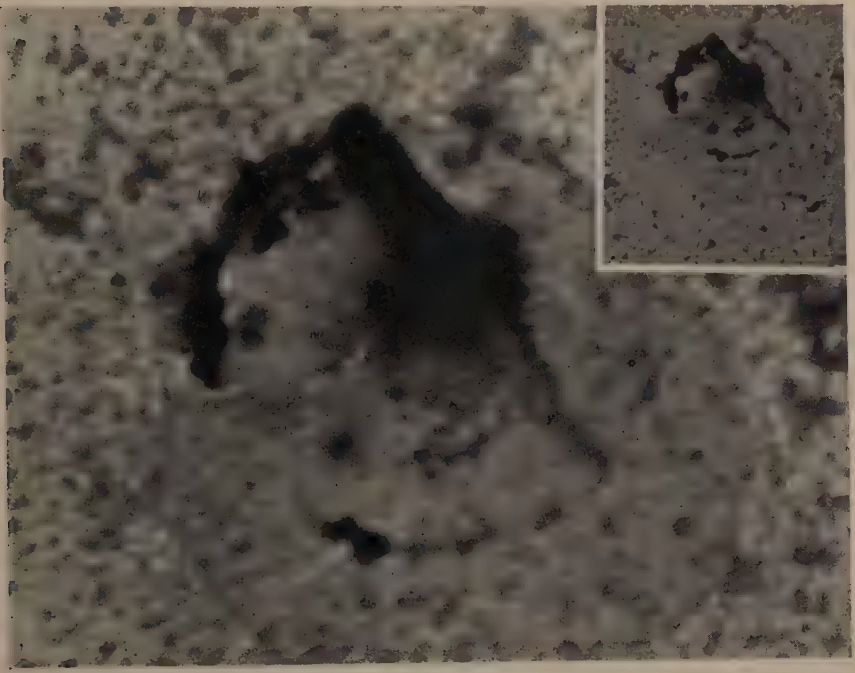

Fig. 8.—Cracked recycle stock residue (101-5).
14,600 and 58,400 diameters.

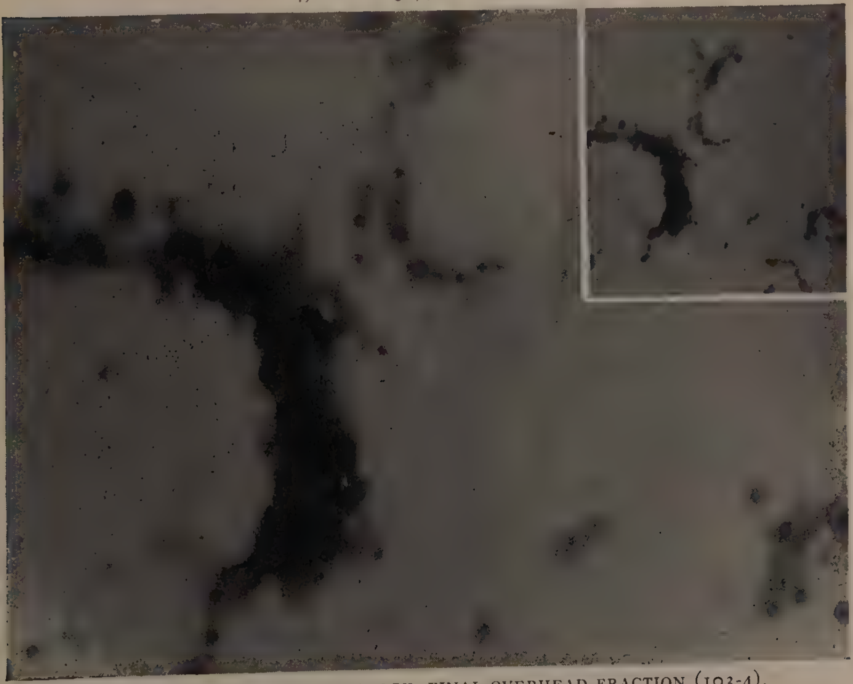

Fig. 9.—Cracked recycle stock, final overhead fraction (103-4).
14,600 and 58,400 diameters.

asphalts. Table 1 is a summary of qualitative experiments for several solvents with Greeley crude oil. The significant point of this table is that the dilution with benzene indicates that no precipitate is formed. The entire contents of the test tube containing the benzene solution is uniform in color, and no particles appear at the bottom.

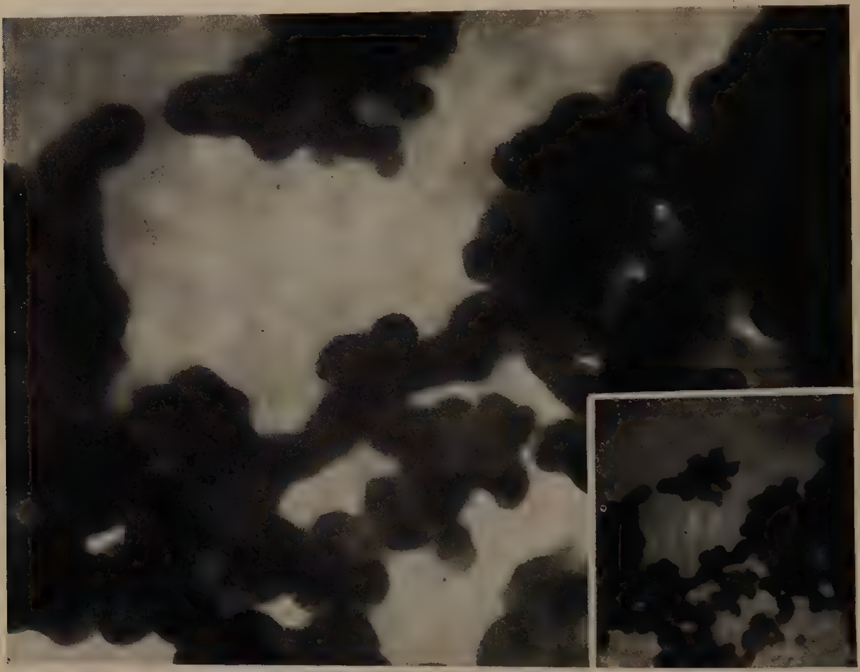

FIG. 10.—CALIFORNIA CRUDE TREATED WITH PETROLEUM ETHER (209-2). 9300 and 37,200 diameters.

As a check upon the precipitating power of benzene, a slide was prepared of the original California crude oil, and this slide was washed with benzene. Fig. 13 is the photograph of this specimen, indicating that the benzene definitely causes the formation of asphaltic particles. Earlier, in Fig. 10, it was shown that petroleum ether caused the precipitation of particles.

CONCLUSIONS

Particles observed after treatment of the crude oil with solvent are believed to be initially in a highly divided state. Particles as small as 0.01 micron in diameter have been observed and the failure to observe particles in the undiluted and unwashed crude oils would indicate that these asphaltic substances were present in particles that, if they still could be called particles, must be less than 0.01 micron in

TABLE 1.—*Precipitation of Asphaltics from Greeley Crude Oil by Several Solvents*

Solvent	Relative Amounts[a] of Asphaltics Produced	Remarks
Iso-octane	1.00	Small and powdery
Petroleum ether	0.84	Small and powdery
Iso-hexane	0.67	Small and powdery
Acetone	0.33	Hard and brittle
Kerosene	0.08	Small and powdery
Carbon tetrachloride	0.00	
Benzene	0.00	

[a] Using Iso-octane as a basis.

diameter. Since 0.01 micron is a very small dimension, and is numerically equal to 100 Ångstrom units, it is well worth while to consider the size of molecules themselves. if the molecular weight were 300,000 a particle of this size would represent only one molecule. In any event, these aggregations of molecules cannot be seen with the electron microscope, and can be little more than an association of a relatively small number of molecules.

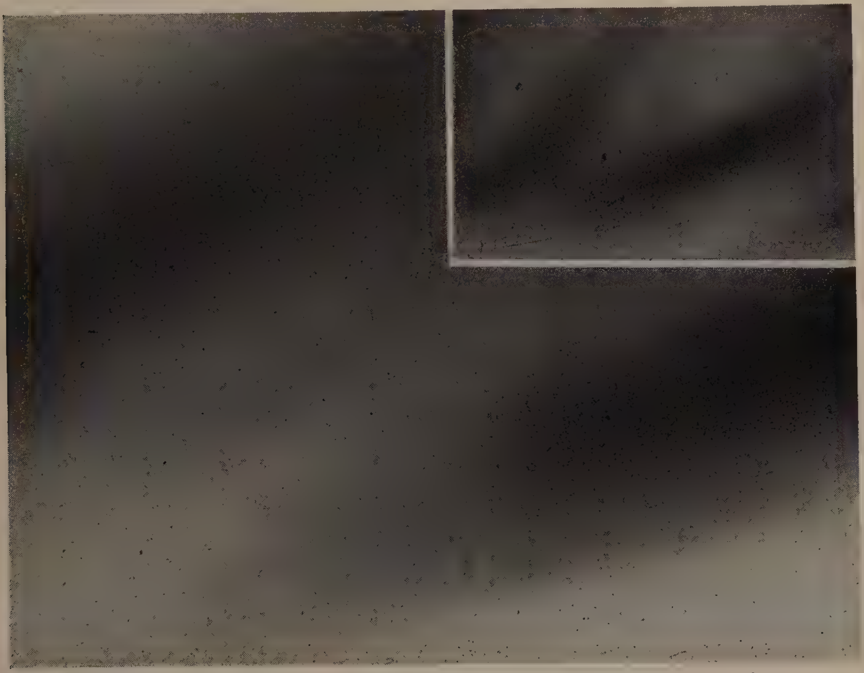

FIG. 11.—CALIFORNIA CRUDE OIL. NO SOLVENT TREATMENT (216-2). 4300 and 37,200 diameters.

From ordinary knowledge of the molecular weights of hydrocarbon oils, it is known that the molecular weight of an asphaltic substance surely is in excess of 1000. Pfeiffer and Saal[17] estimate the molecular weight of the asphaltene they describe as the nucleus of the asphaltic particle to be from 10,000 to 140,000. The number of molecules of a given molecular weight may be computed for any given size of particle if the density of the asphaltic substances is assumed to be 1 gram per cubic centimeter. Using 6.06×10^{23} as the number of molecules in a gram-molecular weight of a substance, a particle 0.01 micron in diameter would contain 300 molecules of an asphaltic substance of molecular weight 1000, while

The electron microscope definitely has proved that asphaltic particles in the colloidal range may be formed by the use of solvents on crude oils. The state of the asphaltic substances in the initial crude oil has been shown to be either molecular or an association of a relatively small number of molecules, dependent upon the molecular weight of the asphaltic compounds. No observations have been made in the transition of the asphaltic substance from its initial stage to the definite particle that conflict with the previously postulated Micelle theory.[15,17]

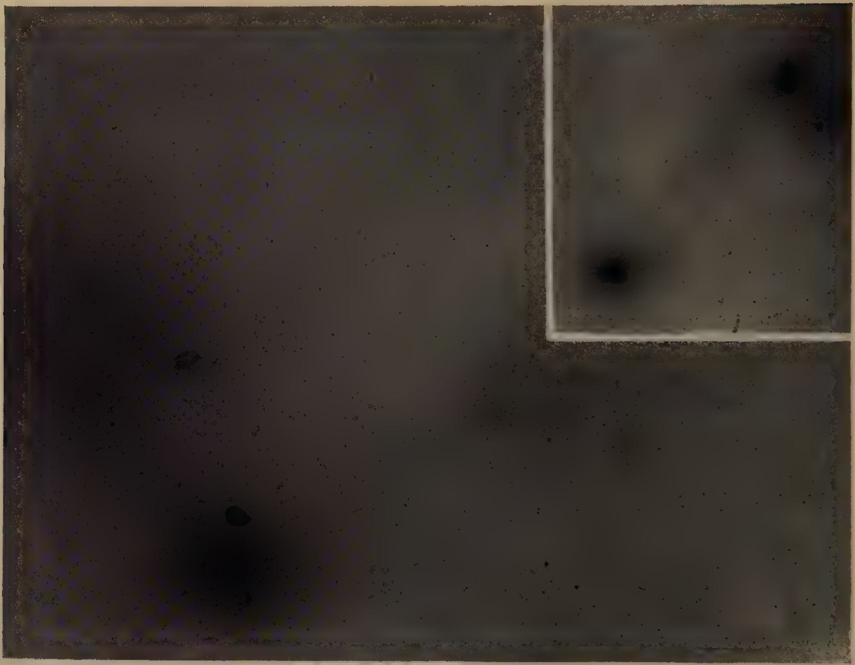

FIG. 12.—CALIFORNIA CRUDE OIL. NO SOLVENT TREATMENT (369-4).
9300 and 37,200 diameters.

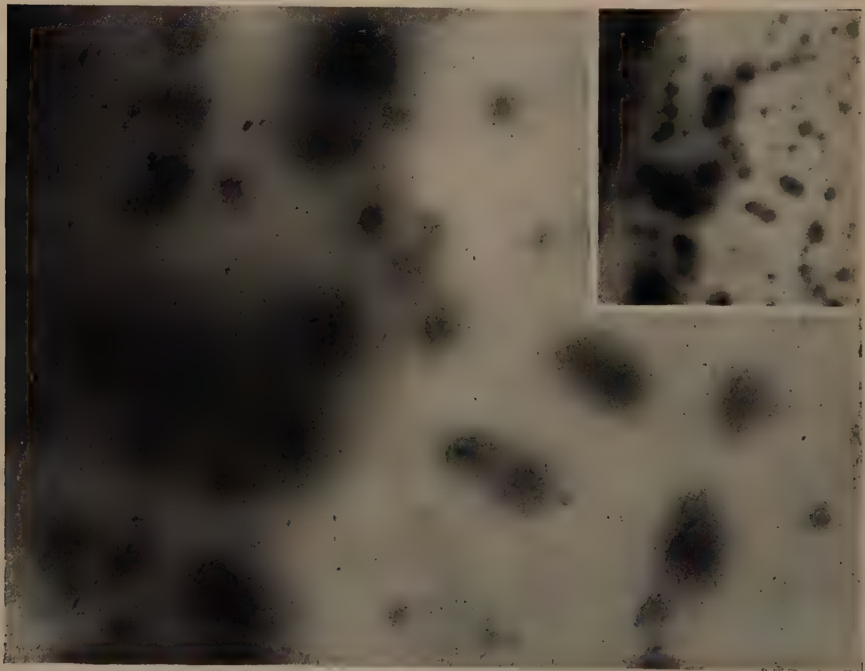

FIG. 13.—CALIFORNIA CRUDE OIL TREATED WITH BENZENE (369-2).
9300 and 37,200 diameters.

II. Investigations from the Colloidal Standpoint

By G. W. Preckshot and D. L. Katz

Earlier work on multiple-phase hydrocarbon systems showed that asphaltic substances were precipitated from crude oil by dissolving gaseous hydrocarbons with increasing pressure.[23] Bitumen or asphaltic material is precipitated in the flow lines and oil and gas separators of wells in the Vedder zone of the Greeley field in California by a decrease in pressure. The same result is obtained by opposite changes in composition, as far as the light hydrocarbons are concerned. Added work on the effect of temperature and pressure upon crude oils precipitating asphalt indicated that the problem should be studied from the colloidal standpoint. This section of this paper discusses electrodeposition of asphaltic particles, the supercentrifuging of oils containing asphaltic substances, and the precipitation of the asphalt by electrical phenomena occurring during flow of the oil through porous media.

Effects of Temperature and Pressure upon Greeley Crude Oil

A subsurface sample of crude oil was obtained from a well in the Greeley field at a depth to ensure a single-phase sample, since the well fluid was undersaturated at the bottom-hole pressure and temperature. This sample was transferred under pressure and shipped in a single phase to the laboratory at the University of Michigan, through the courtesy of the Standard Oil Company of California. The sample was transferred from the pressure container to the equilibrium cell[23] while it was maintained in a single phase at the sampling temperature of 178°F. Observations of this sample during pressure reductions and temperature changes did not indicate any precipitation of asphalt or bitumen.

Another sample of this crude oil under pressure was passed through a filter at high pressure and then the pressure was reduced to atmospheric. The final oil was filtered without evidence of any asphaltic substances. The atmospheric crude oil from the same well was brought into contact with some of the precipitated bitumen, and natural gas was added to bring it up to the initial reservoir conditions. The sample was stirred during a long period of time, then the fluid portion was transferred from the equilibrium cell under pressure to another pressure container. The gas was released from this sample and the remaining liquid was filtered without evidence of any solid asphaltic substances. These results were rather discouraging for finding any effects of temperature, pressure, or composition of gaseous substances on the solubility of asphalt in crude oil. All of this information pointed in the direction of surface phenomena or colloid chemistry as an important basis for studying asphalt precipitation.

Electrodeposition of Asphaltic Particles

One of the characteristics that colloidal particles may possess is an electric charge; therefore the imposition of a potential across a small body of oil should cause colloidal particles, if present, to migrate to one of the electrodes. The crude oil was filtered through No. 214 filter paper and placed in a glass beaker. Into the oil was placed a pair of platinum electrodes spaced from 0.5 to 1.0 mm. apart, and a voltage of 230 volts d.c. was impressed on them. The apparatus is shown in Fig. 14. After some time it was found that only the positive electrode contained the deposit, the negative electrode being free from solid material. This observation indicated that the materials in the crude oil that were deposited on the electrode had a negative charge. Similar observations were made using copper plates and perforated brass electrodes.

The voltage was maintained across the electrodes over a period of several days.

Then the oil was filtered through the same quality of filter paper. A definite sludge was found by this filtration; upon drying, the sludge resembled the bitumen, which was precipitated as the oil flowed from the well in this field.

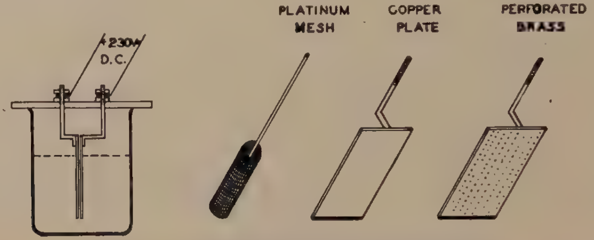

Fig. 14.—Electrodeposition apparatus.

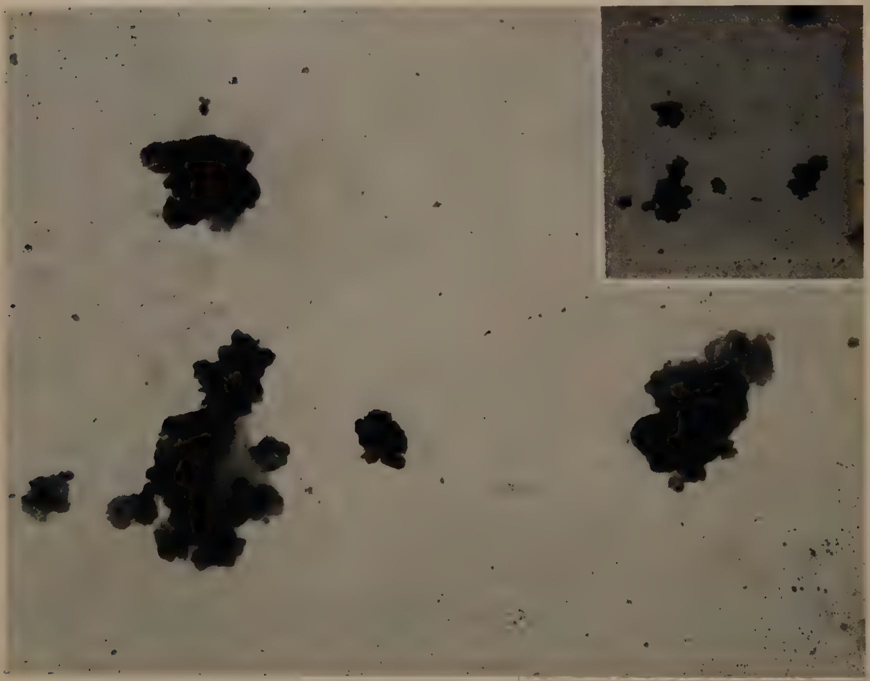

Fig. 15.—Bitumen electrodeposited from California crude and dispersed in benzene (476-3).
9300 and 37,200 diameters.

A sample of this sludge or deposited bitumen was suspended in benzene and used for preparing specimens for the electron microscope. Fig. 15 is the electron photomicrograph of the electrodeposited particles. The large dark particles apparently are an agglomerate of a number of smaller particles, while the large number of tiny faint spots in the background apparently are dispersed particles that are not in the same focus as the larger particles.

Supercentrifuging of Oil·

The supercentrifuge throws out particles from the solution whether or not they are colloidal, provided there is a difference in density between the particles and the solution, and provided that the particles are large enough to be thrown out over the length of time during which the centrifuge is operated. A solution of the bitumen was prepared using benzene at room temperature, filtered through No. 214 filter paper to remove all the suspended particles greater than about 5 microns in diameter. For 30 min. this solution was centrifuged at about 33,000 r.p.m., in a centrifuge loaned by the Michigan Highway Department Laboratories through the courtesy of Mr. Parr. The sides of the bowl were covered with a small amount of dark material, but the remaining solution was still very dark. The deposit on the wall of the bowl was only a small fraction of the bitumen contained in the centrifuged benzene.

The sample of Greeley stock-tank crude was filtered through No. 214 filter paper, then was centrifuged for 3 hr. at about 40,000 r.p.m., yielding a tiny amount of dark material on the walls of the centrifuge bowl. From calculations using Stokes law, it would require 2 hr. of centrifuging at 40,000 r.p.m. to separate particles 0.05 micron in diameter with a gravity of 1.00 grams per c.c. from a crude oil having a density of 0.833 grams per c.c. Fifty hours of centrifuging would be required for similar particles 0.01 micron in diameter. There is also a possibility that the deposited particles were loosened from the wall of the centrifuge by the swirling action of the liquid during the deceleration of the bowl.

Conclusions drawn from the centrifuging experiments were not satisfactory, but the work indicated that although a small quantity of asphaltic substances was thrown out of the solution the greater portion of the asphalt content of the solution was not removed in this manner.

STREAMING POTENTIAL

The movement of one phase past another phase produces an electrical potential known as a streaming potential. The ability of the streaming potential to cause the precipitation of colloid particles has been demonstrated.[6,7,11,19] Following a rather thorough search of the literature on streaming potential, experiments were devised that proved that asphaltic particles could be precipitated from the California crude oil by flowing it through a porous medium.

Literature

The generation of static electricity by movement of a rubber tire over the pavement or by the flow of gasoline through a rubber hose is relatively common. The two phases become equally but oppositely charged, and the potential produced depends upon the speed at which the two phases are separated and upon the electrical conductivity of the two phases.[16] Little information on petroleum fluids is available for this problem, although a relatively large amount of literature exists on the measuring of the electrical potentials generated and of their danger as a fire hazard.[3,8,9,16,21,22]

In aqueous solutions a considerable amount of work has been done upon the streaming potential. If an aqueous solution is passed through a capillary tube, a potential difference is set up between the walls of the tube and the fluid flowing. This potential depends upon the conductivity of the tube and of the fluid as well as the rate of shear of the interface between the two phases. Usually this rate of change of interface between the phases has been related to pressure drop of the fluid flowing through the capillary. Similar experiments can be made using a porous medium instead of a capillary tube. Many investigators have conducted work in this direction, with such variations as coating the capillary wall to change the type of surface between the two phases.[2,12,18,25]

Gortner[9] found a streaming potential of 88.6 volts when using normal caproic acid flowing through an alumina diaphragm under a pressure drop of 5.82 cm. of mercury. Streaming potentials as high as 150 volts have been measured when using glass surfaces and organic liquids.[5] These investigators found that benzene and carbon tetrachloride, molecules that possess no permanent dipole moment, produce no streaming potential.

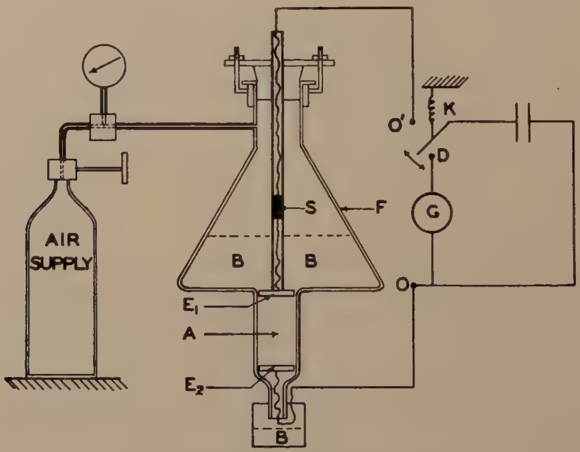

FIG. 16.—STREAMING POTENTIAL APPARATUS.

The effect of the electrical potential created by flow upon aqueous sols has been observed in the form of precipitation of positively charged ferric and chromium oxides.[19] Sahlbom found that negatively charged arsenic trisulphide and other negatively charged substances could not be precipitated by flowing them through the same glass capillaries.[6,19] To cause precipitation of the ferric oxide sol, it was necessary to have a capillary diameter smaller than 0.14 to 0.16 mm. Precipitation took place almost immediately at the entrance to the capillary, provided the diameter was small enough. The precipitate was carried up into the capillary by the force of the flowing fluid. The imbibing of chromium and ferric oxide sols into dry filter paper causes a similar precipitation at the boundary of the paper and the liquid.[6,7] This phenomenon does not occur when the filter paper is previously wetted with distilled water.

Platinum has been precipitated from the aqueous platinum sol by bubbling oxygen through the solution. Nothing happened when hydrogen was bubbled through the same sol for a period of 3 hr.[11] The oxygen acquired a negative charge and the sol a positive charge; the charge on the colloidal platinum in the sol was negative. The charge was neutralized and the platinum was precipitated. The hydrogen caused no precipitation because it charged the sol negatively or reinforced the colloidal platinum in the sol.

The mechanism of precipitation of colloid particles by the streaming potential is similar to that of electrodeposition. In the former the charge of the particle is neutralized by the opposite charge on the fluid while in the latter the contact of the particle with the electrode neutralizes the charge on the particle and causes it to be precipitated. A common process of the nature just described is the electrodeposition of colloidal rubber.[20]

In a review of the literature, a general impression is received that the flow of crude oil through a porous medium could cause the precipitation of asphaltic particles, known as bitumen.

Experimental Work

A simple glass cell (Fig. 16), to permit streaming potential measurements was constructed after the apparatus described by Gortner.[9] Experiments were conducted with this apparatus, using a porous medium at *A* through which the fluid *B* was forced by air displacement. The potential difference between the ends of the porous solid was measured by means of a ballistic galvanometer and condenser using E_1 and E_2 as electrodes. An ordinary potentiometer could not be used for this purpose because the source of supply of electrons generated was not enough to flow through the line and actuate the galvanometer to get reproducible results. The use of a condenser in the line with periodic discharging through the ballistic galvanometer was found satisfactory for measuring both high and low potentials.

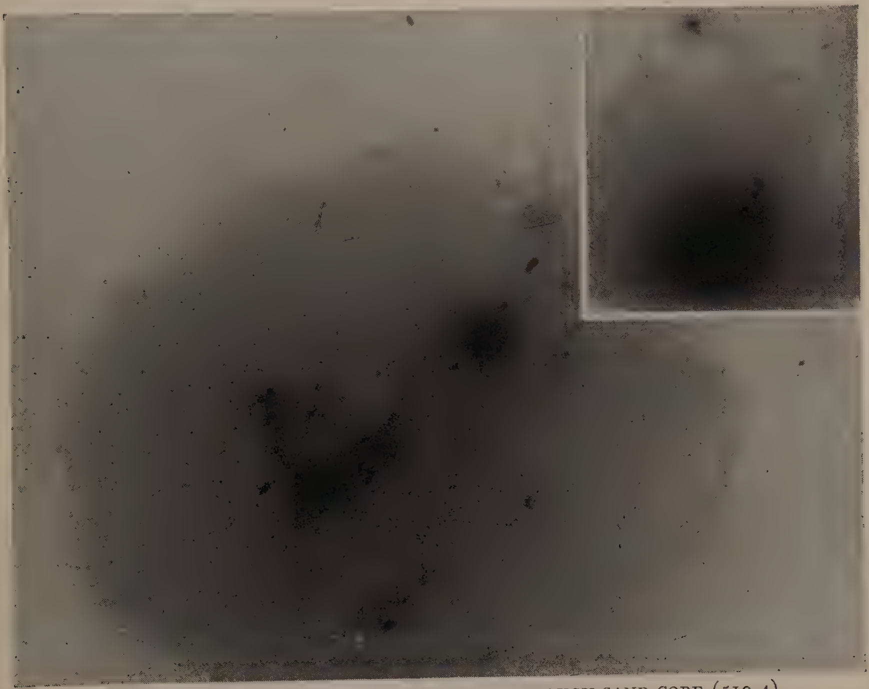

FIG. 17.—GREELEY CRUDE AFTER PASSING THROUGH SAND CORE (519-4). 9300 and 37,200 diameters.

Five experiments were made, using three fluids and two porous solids (Table 2). The alumina core had a relatively low permea-

TABLE 2.—*Experimental Streaming Potentials*

Streaming Fluid	Core and Charge	Pressure Drop, Lb. per Sq. In.	Flow Rate, C.C. per Min.	Time of Condenser Charge, Min.	Maximum Potential, Volts
n-butyl acetate	Alumina (−)	29.9	0.89	30.00	2.77
Natural gasoline[a]	Alumina (−)	23.6	3.09	8.10	0.0044
Natural gasoline[a]	Alumina (−)	19.0–23.6		19.75	0.0196
Greeley crude	Alumina (−)	23.6	0.14	77.00	27.80
Greeley crude	Sand (−)	29.9	113.35	1.50	0.50

[a] 14 lb. Reid V.P. (from Oklahoma City).

bility, which was reflected in the low flow rate at the pressures used. The maximum potential observed in each experiment is given in the table. Measurable potentials were found in all the experiments. The sand had a relatively high permeability, which permitted a high flow rate for the pressure drop of 29.9 lb. per sq. in. The potential was relatively low with the Greeley crude oil, but it should be noticed that the time of charging was only 1.5 min. The low potentials with the natural gasoline are not easily explained but may have something to do with the conductivity of the fluid.

With this apparatus, it was not possible to determine the sign of the charge on the core directly. However, using the information from Gortner,[9] who reported that alumina was negatively charged when normal butyl acetate was passed through it, measurements of Table 2 indicated that both the alumina and sand were negative. The calibration of the ballistic galvanometer showed that electrode E_1 had the same sign of charge throughout the five tests.

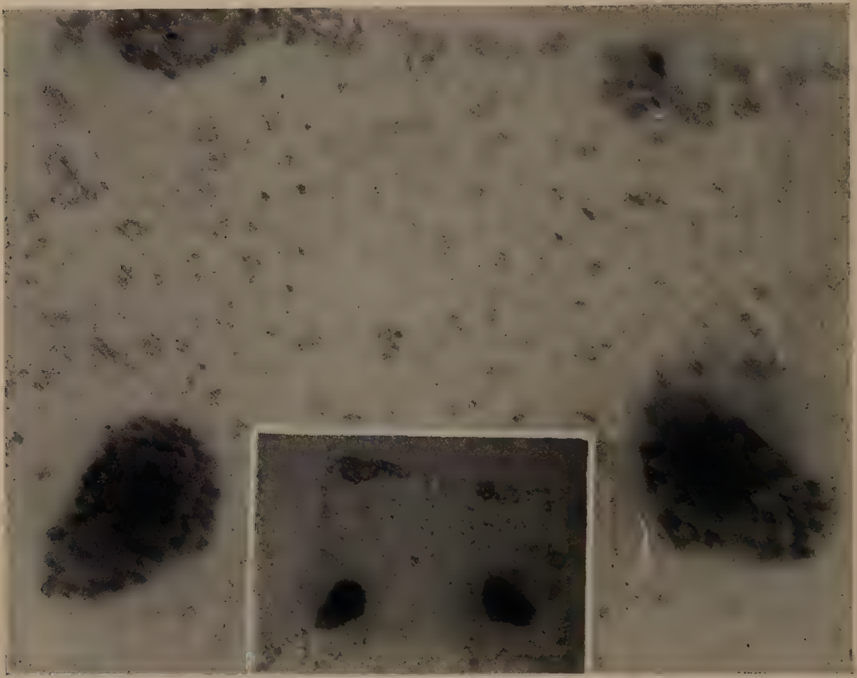

FIG. 18.—BITUMEN PARTICLE REMOVED FROM ALUMINA CORE WITH BENZENE WASH (519-3). 9300 and 37,200 diameters.

When the Greeley crude oil was passed through the alumina core, the first 3 c.c. that passed through had a very definite green cast and resembled a good grade of lubricating oil rather than the original dark colored oil. These 3 c.c. were followed by 18 c.c., which were lighter than the original but darker than the first 3 c.c. No visual changes were observed as the oil passed through the sand.

A portion of the first 3 c.c. of the Greeley crude that passed through the alumina was spread on water and examined under the electron microscope. It was obvious to the operator that particles were present, although the photograph was not clear. No particles were found in the second portion, 18 c.c., of the Greeley crude. Fig. 17 is an electron photomicrograph of the material removed from the alumina when it was washed with benzene following the passing of the Greeley crude through the core. This indicated that the benzene removed asphaltic particles from the core even though the initial crude contained no asphalt particles that could be identified by the microscope. A specimen containing particles of alumina was observed in order that they might not be mistaken for the asphaltic particles.

Greeley crude passed through sand *A* as in Fig. 16 was spread on water and viewed with the electron microscope; Fig. 18 shows the presence of bitumen particles. Particles did not appear in the photographs of the original oil (Figs. 11 and 12) but do appear after it had flowed through the sand. It appears logical that the streaming or frictional potential was responsible for their formation.

Conclusions

Studies of the effect of temperature and pressure on the precipitation and solution of asphaltic substances in crude oils indicated that the problem was more closely related to surface or colloidal chemistry than to the usual phase equilibria. In colloidal systems, boundary conditions produce a charge on a particle. Electrodeposition experiments removed bitumen particles from Greeley crude oil that originally did not contain particles larger than 0.01 micron in diameter. Streaming-potential experiments demonstrated that crude oil flowing through sand produces a potential. This electrical potential appears to be responsible for the formation of the asphaltic particles found in crude oil that has passed through sand. Parallel phenomena are likely to occur when crude oil flows through a porous reservoir rock.

Acknowledgment

As noted throughout the paper, several groups have assisted in this research. Special credit is due the members of the Physics Department at the University of Michigan who have contributed to this paper.

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DISCUSSION

(*P. E. Fitzgerald presiding*)

W. A. Bruce,* Tulsa, Okla.—It is believed that the substance described by the authors as being prevalent in California crudes has been found in crude oil from Village, Arkansas. This bituminous material has been observed in the tubings of several of the wells.

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* Carter Oil Co.

Phase Behavior in the Methane-propane-*n*-pentane System*

By R. H. Dourson,† B. H. Sage,‡ Member A.I.M.E., and W. N. Lacey‡

(Los Angeles Meeting, October 1942)

Abstract

The compositions of coexisting phases in the methane-propane-*n*-pentane system were determined at 160° and 220°F. throughout the two-phase region, at pressures above 500 lb. per sq. in. The experimental results permitted the calculation of gas-liquid equilibrium constants as well as the establishment of the critical behavior of this ternary system.

Introduction

Although many binary paraffin hydrocarbon systems have been investigated, the experimental work relating to the phase behavior of ternary paraffin hydrocarbon mixtures at elevated pressures is relatively scarce, being limited to a study of the methane-propane-*n*-pentane system at 100°F.[1,2] However, Guter and co-workers have studied the phase behavior of the methane-ethane-ethylene system at relatively low temperatures. Information concerning the phase behavior of ternary systems is of value in predicting the behavior of the components in multicomponent systems, since the influence of pressure, temperature, and concentration may be individually ascertained. In the light of the importance of such information, the study of this ternary system was extended to higher temperatures in order to increase the field of temperature in which the data could be applied.

Since all states encountered in this investigation are above the critical temperature of methane, the details of its phase behavior are not of direct significance. The properties of propane in the heterogeneous region were taken from a correlation[3] based upon recently published data. The corresponding information for *n*-pentane was taken from experimentally measured vapor pressures and volumetric data.[4] The methane-propane system has been studied throughout the two-phase region at temperatures above 70°F.,[5] while the phase behavior of the propane-*n*-pentane system has been established for temperatures above 160°F.[6] The volumetric and phase behavior of the methane-*n*-pentane system has been studied in detail.[7,8] The experimental measurements serve to establish with adequate accuracy the phase behavior of the components and of the constituent binary systems for this ternary system. It is believed that, with the exception of the measurements for the methane-propane system, the uncertainties in the earlier data relating to the pure substances and the binary mixtures are probably less than those associated with the values reported here.

Method

The methods and apparatus employed in this investigation have been described.[1,7] In principle, the method involved the withdrawal of samples of the coexisting gas and liquid phases from a vessel containing a heterogeneous mixture of methane, propane and *n*-pentane. Provision was made so that

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* The first paper on this subject appeared in *Trans.* A.I.M.E. (1941) **142**.

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[1] References are at the end of the paper.

the samples could be withdrawn under substantially isobaric-isothermal conditions, after equilibrium had been attained. The composition of the samples withdrawn was ascertained by the conventional low-temperature fractionation procedure. Duplicate measurements at identical states indicated an uncertainty in the mol fraction of each of the components of approximately 0.001. It is believed that the equilibrium pressure was measured by means of a fluid-pressure balance with an uncertainty of not more than one pound per square inch, while the temperature relative to the international platinum scale was established within 0.1°F.

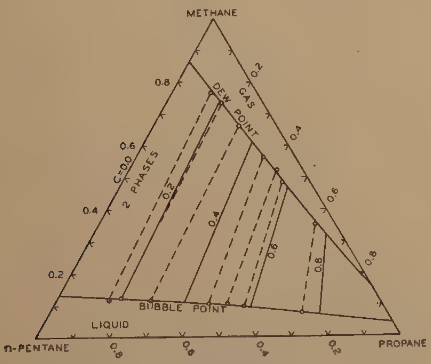

FIG. 1.—MOLAL COMPOSITION DIAGRAM AT 500 POUNDS PER SQUARE INCH AND 160°F.

MATERIALS

The methane employed in this investigation was obtained from the Buttonwillow field, California, and as received at the laboratory contained approximately 0.003 mol fraction carbon dioxide and less than 0.001 mol fraction hydrocarbons other than methane and was saturated with water. The gas was passed through granular beds of calcium chloride, activated charcoal, magnesium perchlorate, and ascarite, at pressures in excess of 400 lb. per sq. in. It was then cooled to a temperature of approximately minus 115°F. It is believed that this material when ready for use contained less than 0.001 mol fraction of material other than methane.

The propane utilized was obtained from the Phillips Petroleum Co., whose special analysis indicated that the impurities were less than 0.005 mol fraction. Measurements of the vapor pressure of this material indicated a change during isothermal condensation from dew point to bubble point of less than 0.15 lb. per sq. in. at 160°F. The *n*-pentane was obtained from the same source and the analysis furnished indicated that this material was made up of 0.995 mol fraction *n*-pentane and 0.005 mol fraction isopentane. Prior to its use the pentane was subjected to boiling at a temperature of approximately 100°F. for an extended period, in order to remove difficultly condensable gases such as oxygen or nitrogen.

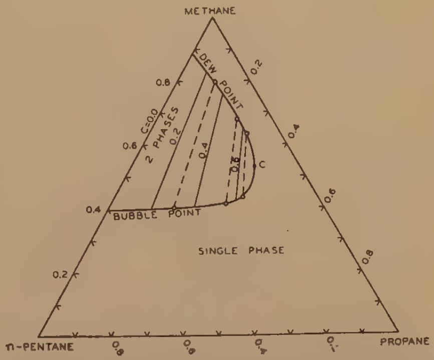

FIG. 2.—MOLAL COMPOSITION DIAGRAM AT 1500 POUNDS PER SQUARE INCH AND 160°F.

EXPERIMENTAL RESULTS

The detailed experimental results obtained at 160° and 220°F. for pressures of 500, 1000, 1500 and 2000 lb. per sq. in. are recorded in Table 1. It is believed that the uncertainty in the values there recorded is not more than 0.002 mol fraction. The experimental results obtained at 500 and 1500 lb. per sq. in. at 160°F. are portrayed in Figs. 1 and 2, respectively. The compositions of the coexisting phases in the methane-pentane system and in the methane-propane system were obtained from information available in the literature.[5,7,8] The dotted lines connect the experimentally determined compositions of the coexisting phases while the solid combining lines[9,10] correspond to even values of the parameter *C*, which is defined[1] as $\mathbf{X}_3/(\mathbf{X}_3 + \mathbf{X}_5)$, when $\mathbf{X}_3$ is the mol fraction of propane in the liquid phase and $\mathbf{X}_5$ is that of n-pentane. The combining lines corresponding to the even values of the ratio *C* were obtained from data smoothed with respect to pressure, temperature, and composition. A comparison of the relative slopes of the experimentally established

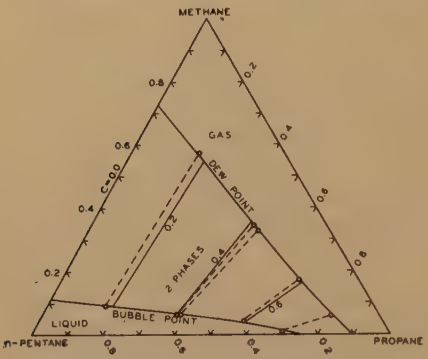

FIG. 3.—MOLAL COMPOSITION DIAGRAM AT 500 POUNDS PER SQUARE INCH AND 220°F.

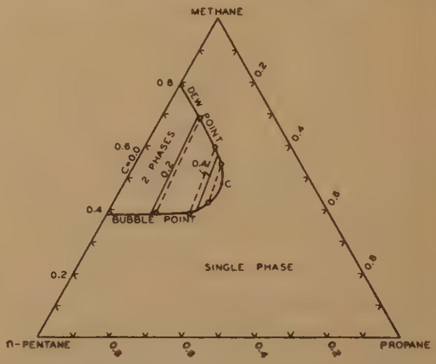

FIG. 4.—MOLAL COMPOSITION DIAGRAM AT 1500 POUNDS PER SQUARE INCH AND 220°F.

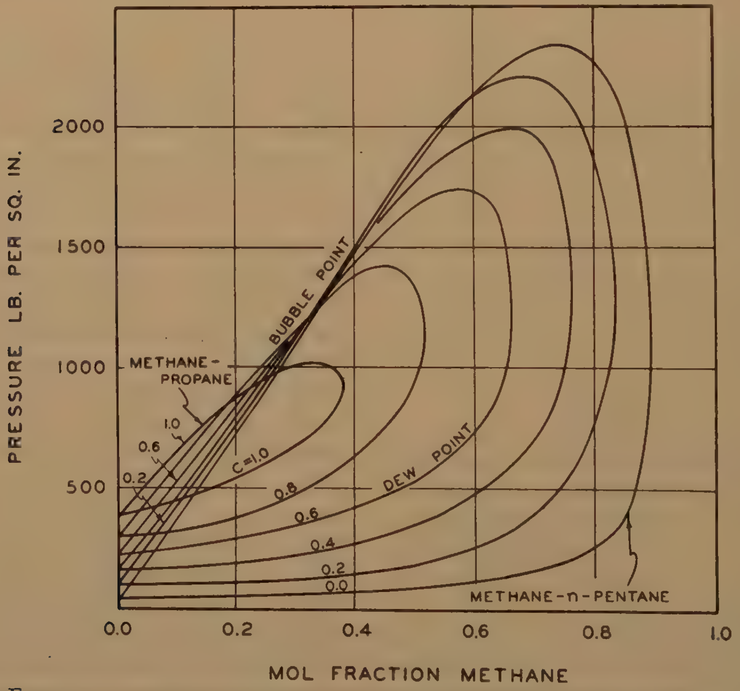

FIG. 5.—EFFECT OF METHANE UPON THE DEW-POINT AND BUBBLE-POINT PRESSURES AT 160°F.

and the smoothed combining lines is an added indication of the accuracy of the experimental data.

TABLE 1.—*Experimentally Determined Compositions of Coexisting Phases*[a]

Pressure, Lb. per Sq. In. Absolute	Gas Phase Methane	Gas Phase Propane	Gas Phase *n*-Pentane	Liquid Phase Methane	Liquid Phase Propane	Liquid Phase *n*-Pentane
			160°F.			
500	0.768[a]	0.106	0.126	0.119	0.141	0.740
	0.736	0.152	0.112	0.121	0.175	0.704
	0.661	0.238	0.101	0.116	0.259	0.625
	0.563	0.350	0.087	0.107	0.421	0.472
	0.524	0.406	0.070	0.103	0.474	0.423
	0.485	0.439	0.076	0.098	0.522	0.380
	0.352	0.595	0.053	0.075	0.693	0.232
1,000	0.840	0.068	0.092	0.261	0.124	0.615
	0.761	0.157	0.082	0.272	0.287	0.441
	0.678	0.249	0.073	0.247	0.399	0.354
	0.613	0.324	0.063	0.248	0.491	0.261
	0.543	0.406	0.051	0.246	0.583	0.171
1,500	0.798	0.105	0.097	0.401	0.181	0.418
	0.679	0.223	0.098	0.414	0.321	0.265
	0.634	0.272	0.094	0.434	0.357	0.209
2,000	0.820	0.038	0.142	0.538	0.056	0.406
	0.770	0.076	0.154	0.540	0.140	0.320
			220°F.			
500	0.571	0.190	0.239	0.091	0.160	0.749
	0.345	0.451	0.204	0.062	0.377	0.561
	0.329	0.472	0.199	0.061	0.389	0.550
	0.170	0.666	0.164	0.043	0.570	0.387
	0.059	0.809	0.132	0.010	0.697	0.293
1,000	0.714	0.106	0.180	0.228	0.138	0.634
	0.669	0.155	0.176	0.223	0.192	0.585
	0.566	0.264	0.170	0.214	0.306	0.480
	0.521	0.318	0.161	0.208	0.370	0.421
	0.397	0.463	0.140	0.197	0.516	0.287
1,500	0.689	0.108	0.203	0.390	0.133	0.477
	0.598	0.194	0.388	0.388	0.228	0.384
	0.542	0.239	0.219	0.422	0.262	0.316

[a] Compositions are expressed as mol fraction.

In Fig. 1 the regions of stability of the phases are indicated. At a pressure of 1500 lb. per sq. in. and a temperature of 160°F. the pressure is in excess of the maximum two-phase pressures for the propane-*n*-pentane system and for the methane-propane system. Therefore, only a single homogeneous phase may persist at compositions corresponding to these binary systems. The critical state for the ternary mixture at this pressure and temperature is that point at which the combining lines disappear tangentially into the dew-point and bubble-point curves, which become continuously identical at this point. Its approximate location is indicated by the point *C* in Fig. 2.

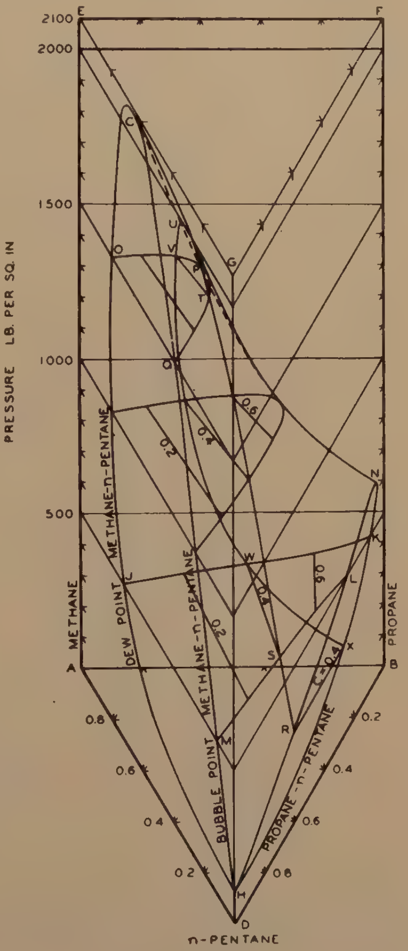

FIG. 6.—PRESSURE-COMPOSITION DIAGRAM AT 220°F.

Typical experimental results obtained at 220°F. are portrayed in Figs. 3 and 4. In these cases the temperature is above that corresponding to the critical state of propane, therefore no heterogeneous region obtains at compositions corresponding to the methane-propane system. However, a heterogeneous region is found for the propane-*n*-pentane system at this temperature and a pressure of 500 lb. per sq. in. At a temperature for which the vapor pressure of propane is equal to the pressure in question the bubble-point and dew-point curves would intersect at a composition corresponding to pure propane. This situation would obtain at a temperature of about 185.1°F.

TABLE 2.—*Equilibrium Constants for Components of Methane-propane-n-pentane System*

Pressure, Lb. per Sq. In. Absolute	C[a]	Equilibrium Constants			Composition of Gas Phases			Composition of Liquid Phase		
		Methane	Propane	*n*-Pentane	Methane	Propane	*n*-Pentane	Methane	Propane	*n*-Pentane
160°F.										
500	0.0	6.36	0.822	0.154	0.867	0.000	0.133	0.136	0.000	0.864
	0.2	5.98	0.829	0.160	0.743	0.145	0.112	0.124	0.175	0.701
	0.4	5.49	0.837	0.170	0.612	0.297	0.091	0.112	0.355	0.533
	0.6	4.99	0.848	0.185	0.472	0.461	0.067	0.095	0.543	0.362
	0.8	4.34	0.863	0.210	0.322	0.639	0.039	0.074	0.741	0.185
	1.0	3.69	0.879	0.250	0.159	0.841	0.000	0.043	0.957	0.000
1,000	0.0	3.26	0.543	0.147	0.893	0.000	0.107	0.274	0.000	0.726
	0.2	3.11	0.548	0.159	0.826	0.080	0.094	0.266	0.147	0.587
	0.4	2.89	0.569	0.181	0.752	0.168	0.080	0.261	0.296	0.443
	0.6	2.58	0.620	0.221	0.657	0.277	0.066	0.255	0.447	0.298
	0.8	2.09	0.727	0.324	0.512	0.439	0.049	0.245	0.604	0.151
	1.0	1.22	0.909	0.930	0.361	0.639	0.000	0.297	0.703	0.000
1,500	0.0	2.23	0.554	0.190	0.885	0.000	0.115	0.398	0.000	0.602
	0.2	2.09	0.566	0.213	0.829	0.068	0.103	0.397	0.121	0.482
	0.4	1.90	0.610	0.265	0.758	0.147	0.095	0.400	0.240	0.360
	0.6	1.57	0.732	0.411	0.645	0.258	0.097	0.412	0.353	0.235
2,000	0.0	1.57	0.704	0.318	0.855	0.000	0.145	0.545	0.000	0.455
	0.2	1.45	0.800	0.380	0.789	0.073	0.138	0.546	0.091	0.363
220°F.										
500	0.0	6.31	1.178	0.307	0.728	0.000	0.272	0.115	0.000	0.885
	0.2	6.19	1.178	0.327	0.547	0.215	0.238	0.088	0.182	0.730
	0.4	5.53	1.179	0.357	0.359	0.441	0.200	0.065	0.374	0.561
	0.6	4.29	1.179	0.397	0.167	0.680	0.153	0.039	0.577	0.384
1,000	0.0	3.18	0.760	0.270	0.798	0.000	0.202	0.251	0.000	0.749
	0.2	3.03	0.791	0.294	0.697	0.122	0.181	0.230	0.154	0.616
	0.4	2.71	0.825	0.345	0.577	0.260	0.163	0.213	0.315	0.472
	0.6	2.10	0.884	0.453	0.436	0.420	0.144	0.208	0.475	0.317
1,500	0.0	2.08	0.772	0.333	0.794	0.000	0.206	0.382	0.000	0.618
	0.2	1.86	0.790	0.412	0.695	0.099	0.206	0.374	0.125	0.501
	0.4	1.50	0.840	0.585	0.577	0.207	0.216	0.385	0.246	0.369

[a] Parameter $C = \frac{X_3}{X_3 + X_5}$.

The experimental results recorded in Table 1 were smoothed with respect to pressure, temperature, and composition. The mol fractions of methane, propane, and *n*-pentane in the coexisting gas and liquid phases for temperatures of 100° and 220°F. are recorded in a part of Table 2. The corresponding values of the gas-liquid equilibrium constant are recorded as a function of the ratio *C* defined above. It is believed that the values of the composition of the coexisting phases do not involve uncertainties greater than 0.01 mol fraction.

The influence of pressure upon the mol fraction of methane in the bubble-point liquid and the dew-point gas of the methane-propane-*n*-pentane system is portrayed in Fig. 5. It should be emphasized that dew-point and bubble-point states at the same pressure and temperature do not necessarily coexist. For this reason states at the same pressure on the bubble-point and dew-point curves are not at equilibrium except at rare intervals. The boundaries of the two-phase region for both the methane-propane and the methane-*n*-pentane systems have been indicated in Fig. 5. The abscissa value corresponding to zero mol fraction methane represents the behavior of the propane-*n*-pentane system at a temperature of 160°F. Similar diagrams may be prepared from the data recorded in Table 2 for the behavior of the other components of this ternary system.

If it is desired to depict the influence of composition and pressure upon the behavior of the system in the heterogeneous region, some form of oblique projection may be utilized. Such a pressure-composition diagram for 220°F. is presented in Fig. 6. In each of the exterior planes of the prism is portrayed the behavior of the corresponding binary system. However, at this temperature, which is above the critical temperature of pure propane, there is no heterogeneous region for the methane-propane system. The triangles *ABD* and *EFG* are isobaric planes in which the composition of the system is represented in a fashion analogous to that employed in Figs. 1 to 4, inclusive. The closed loop *HJOCQM* corresponds to the boundaries of the heterogeneous region in the methane-*n*-pentane system. The points *J* and *M* represent the compositions of coexisting gas and liquid phases at a pressure of 500 lb. per sq. in. The line *OQ* connects coexisting phases at a pressure of 1500 lb. per sq. inch.

Similarly the compositions of the coexisting phases in the propane-*n*-pentane system are portrayed by the loop *HRLNKX*. Coexisting gas and liquid phases for a value of *C* of 0.4 are indicated by the points *X* and *R*, respectively. The figure *JWKLM* outlines the heterogeneous region of this ternary system at a pressure of 500 lb. per sq. in. Combining lines for even values of *C* are indicated. Similar loops for 1000 and 1500 lb. per sq. in. are shown. The loop *RSPUVWX* indicates the loci of coexisting phases having a value of *C* of 0.4. The dotted curve *CPN* represents the locus of the critical states at this particular temperature, while the adjacent full curve represents the projection of the boundary surface. These data indicate that the maximum two-phase pressure in this ternary system at 220°F. occurs at a composition corresponding to the critical state of the methane and pentane system.

The influence of temperature upon the phase behavior of this ternary system at a pressure of 1500 lb. per sq. in. is indicated in Fig. 7. The triangle *ABC* forming the base of the prism *ABCDEF* represents the composition of the system in a fashion analogous to that employed in Figs. 1 to 4, inclusive. In this triangle is portrayed the phase behavior of the methane-propane-*n*-pentane system at 100°F.[1] Combining lines corresponding to even values of the parameter *C* are indicated. Similar information for temperatures of 160°, 220°, and 280°F. are shown in this figure. The loop

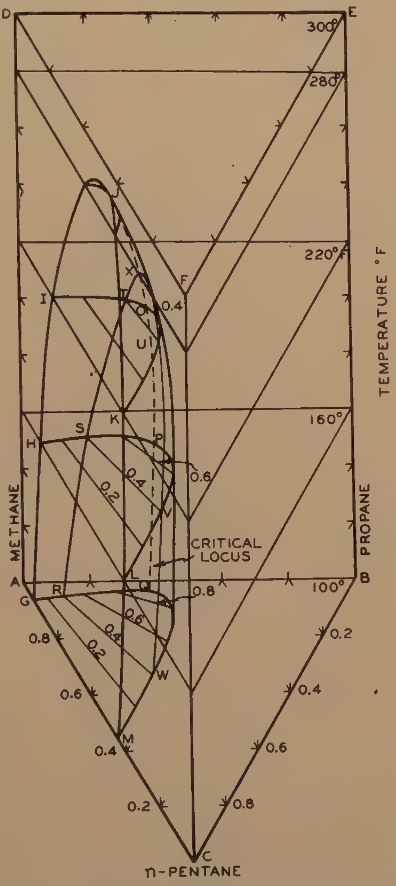

FIG. 7.—TEMPERATURE-COMPOSITION DIAGRAM FOR 1500 POUNDS PER SQUARE INCH.

GHIJKLM represents the influence of temperature upon the phase behavior of the methane-*n*-pentane system at a pressure of 1500 lb. per sq. in. The dotted curve *QPOJ* represents the locus of the critical states of the ternary system at this pressure. The loop *RSTXVW* is a figure of generation and represents the influence of temperature upon the compositions of the coexisting phases for mixtures exhibiting a value of *C* of 0.4. The maximum two-phase temperature of the ternary system for a particular pressure is found at a state corresponding to the critical temperature of the methane-*n*-pentane system at that pressure.

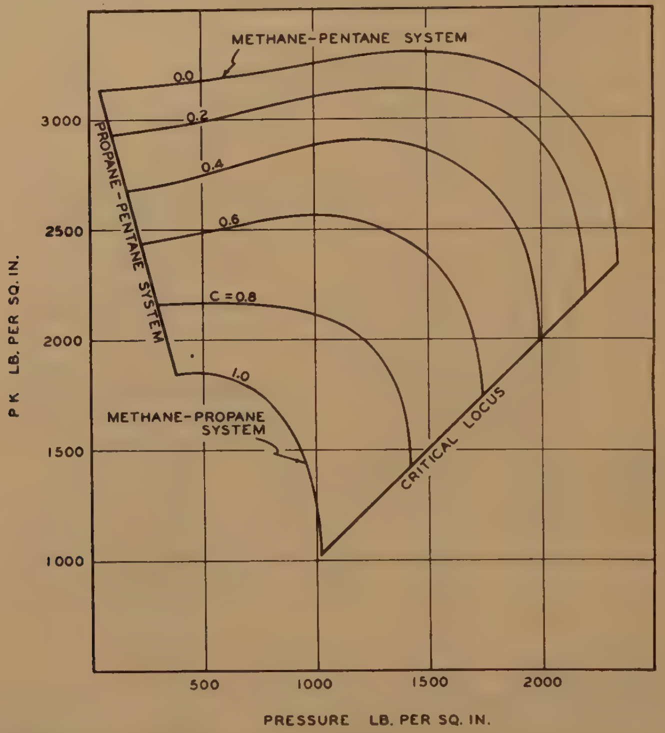

Fig. 8.—Influence of pressure upon equilibrium constant for methane at 160°F.

Equilibrium Constants

The information recorded in Table 2 includes the equilibrium constants for the three components of this ternary system. In Fig. 8 is presented the product of the pressure and the equilibrium constant for methane as a function of pressure for several values of the parameter *C* at 160°F. In this instance the equilibrium constants terminate at a lower pressure corresponding to the equilibrium pressure for the mixture from the propane-*n*-pentane system, which has the proper value of the parameter *C*. The behavior of both the methane-*n*-pentane system and the methane-propane system is indicated, and the higher pressure limit of each of the curves lies at the critical pressure of the corresponding binary system. These data indicate a reasonably regular decrease for the equilibrium constant of methane with an increase in the value of *C*. A similar diagram may be constructed from the recorded data for 220°F. However, in this instance the methane-propane system does not exist in the heterogeneous region and

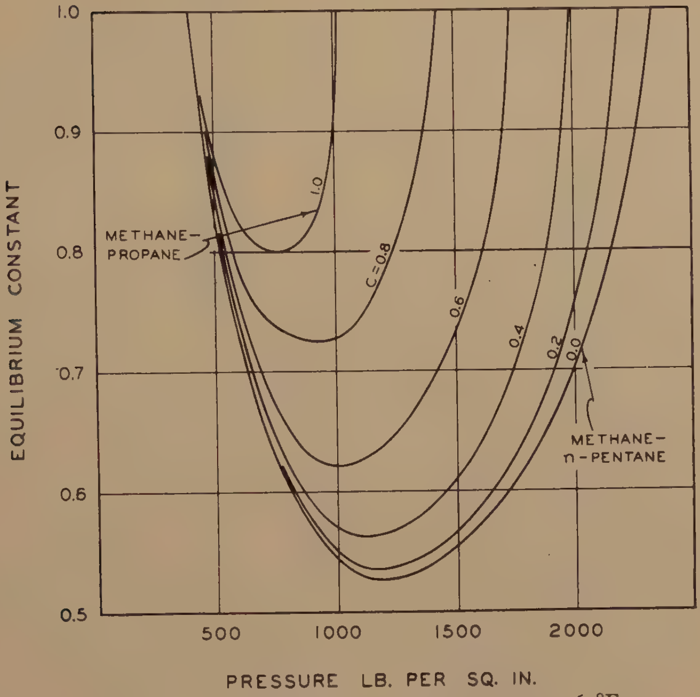

Fig. 9.—Equilibrium constant for propane at 160°F.

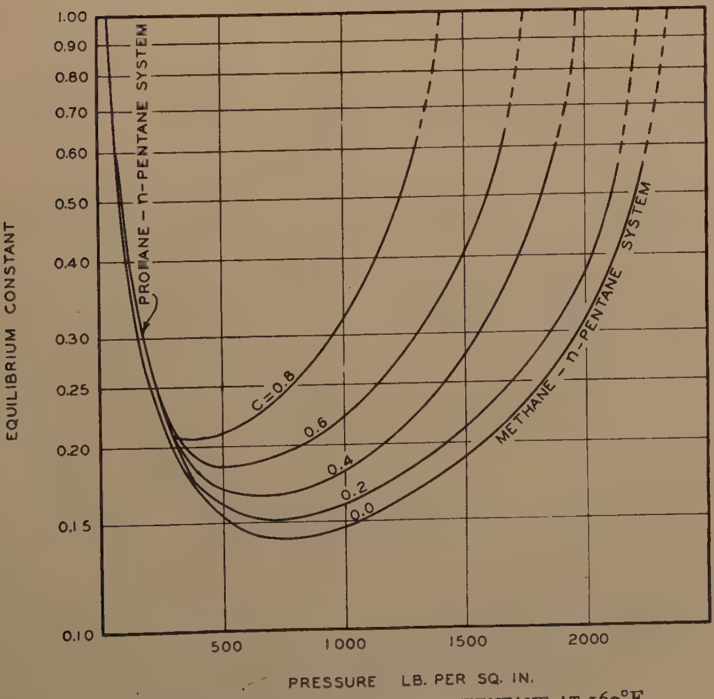

Fig. 10.—Equilibrium constant for *n*-pentane at 160°F.

the critical locus intersects the curve for the propane-*n*-pentane system at a value of C of about 0.94.

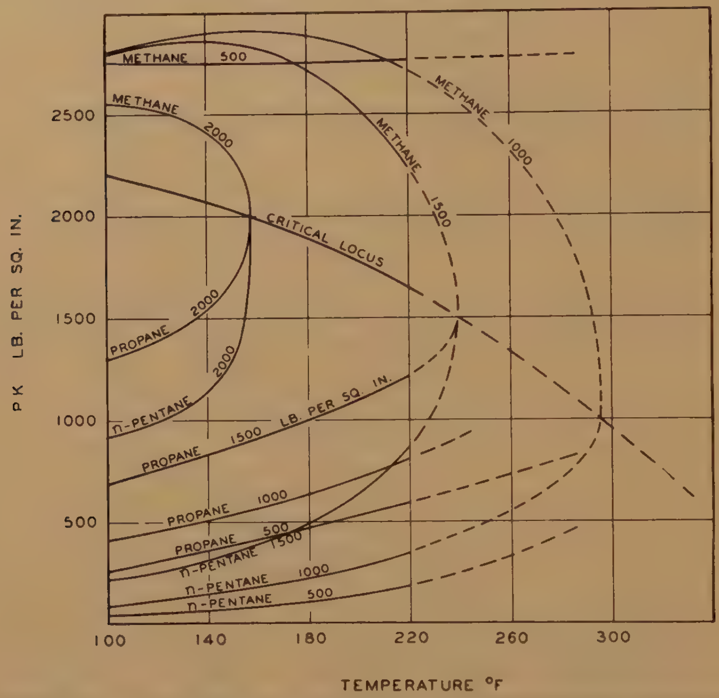

FIG. 11.—EQUILIBRIUM CONSTANTS FOR COMPONENTS IN METHANE-PROPANE-PENTANE SYSTEM FOR THE CASE IN WHICH C EQUALS 0.4.

Values of the equilibrium constant for propane in the ternary system at a temperature of 160°F. are indicated in Fig. 9. These data indicate a progressive increase in the equilibrium constant of this component with an increase in C. The behavior of propane in the limiting case of zero concentration corresponding to the methane-*n*-pentane system is shown. At the lower pressures the influence of the ratio C upon the behavior of this system is small, but at pressures in excess of 500 lb. per sq. in. it becomes of great importance. A similar type of behavior is encountered at 220°F., except that the equilibrium constant for propane is greater than unity at pressures below approximately 700 lb. per sq. in. for all values of C. This is to be anticipated, since propane is the more volatile component in the propane-*n*-pentane system, and this binary system delimits the lower pressures of the heterogeneous region.

Equilibrium constants for pentane in this ternary system are indicated in Fig. 10 for 160°F. In this diagram the logarithmic scale has been employed for the equilibrium constant in order to obtain increased accuracy of presentation at the lower values of K. These data indicate the same general trends as were portrayed in the earlier work at 100°F.[1] The behavior of pentane in the propane-*n*-pentane system and in the methane-*n*-pentane system is shown.

In order to show the interrelation of these equilibrium constants, the product of the equilibrium constant and the pressure for the case in which the quantity C has a value of 0.4 has been depicted for each of the components as a function of temperature in Fig. 11. The information contained in Fig. 11 indicates an increase in this product with an increase in temperature for both propane and *n*-pentane. The value first increases, reaches a maximum, and then decreases, with an increase in temperature in the case of methane. The curves have been indicated by means of dotted lines at temperatures above 220°F., since this represents the maximum temperature at which the composition of the coexisting phases was experimentally investigated. The general behavior is similar to that found for binary systems, but illustrates the influence of the composition of the system upon the equilibrium behavior of the individual components.

ACKNOWLEDGMENTS

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Joule-Thomson Coefficients for Two Natural Gases

By B. H. Sage,* Member A.I.M.E., D. F. Botkin* and W. N. Lacey*

(Los Angeles Meeting, October 1942)

Abstract

Joule-Thomson coefficients for two natural gases were determined at pressures up to 600 lb. per sq. in. throughout the temperature interval between 70° and 310°F. From these primary data and available information relating to the isobaric heat capacities of the components at infinite volume, the heat capacities of these gases were computed throughout the above-mentioned range of pressures and temperatures. The enthalpies of the gases were computed as a function of state and the results compared with values obtained by several methods of prediction currently available.

Table 1.—*Composition of Gas Samples*

Components	Gas A	Gas B
Carbon dioxide	0.0090[a]	0.0420
Methane	0.8255	0.8385
Ethane	0.0901	0.0637
Propane	0.0462	0.0374
Isobutane	0.0074	0.0039
n-butane	0.0126	0.0095
Isopentane	0.0032	0.0016
n-pentane	0.0022	0.0011
Hexanes and Heavier	0.0038	0.0023

[a] Expressed as mol fraction.

Introduction

Experimentally determined Joule-Thomson coefficients for natural gases afford a satisfactory means of checking the accuracy of prediction of their thermodynamic properties from the behavior of the components in the pure state and in binary mixtures. Relatively small samples of these natural gases were available, together with their analyses, and the Joule-Thomson coefficients were investigated at temperatures from 70° to 310°F. throughout as large a range of pressures as the quantities of gas on hand permitted.

Method and Materials

The Joule-Thomson coefficients were determined by measuring the change in temperature resulting from the passage of the gas through a porous thimble with a known pressure difference and under such conditions that the process was substantially isenthalpic. The details of the apparatus employed for this purpose have been described.[1] It is believed that the changes in temperature and pressure were ascertained with an uncertainty of not more than 0.3 per cent. However, as a result of deviations from steady flow, it is probable that uncertainties as large as 2 per cent may exist in the measured Joule-Thomson coefficient.

The gases utilized in this work were taken from high-pressure separators and were dried prior to use by passage over calcium chloride at pressures in excess of 300 lb. per sq. in. The gases were subjected to the conventional fractionation and Orsat analyses. The results are recorded in Table 1. The composition is typical of gases from such sources, with the possible exception of the presence of significant quantities of carbon dioxide in each of the samples.

Experimental Results

The experimental results obtained for the two natural gases are graphically portrayed in Figs. 1 and 2. The experimental

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[1] References are at the end of the paper.

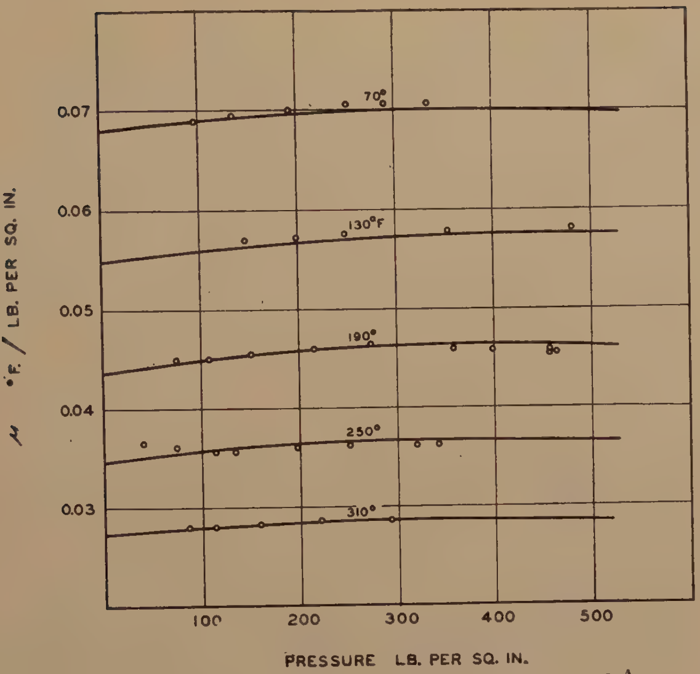

FIG. 1.—JOULE-THOMSON COEFFICIENT FOR NATURAL GAS A.

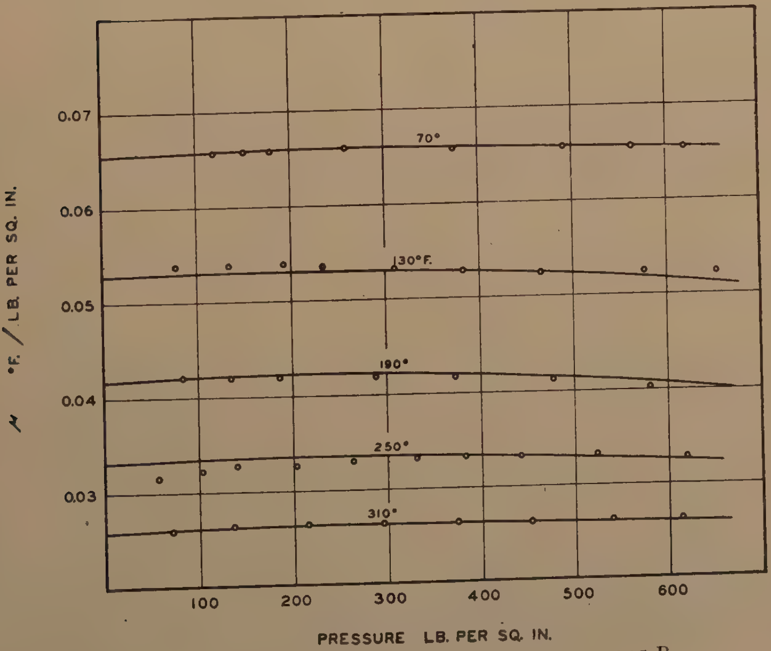

FIG. 2.—JOULE-THOMSON COEFFICIENT FOR NATURAL GAS B.

points are indicated while the curves are based upon values smoothed with respect to temperature and pressure. The digressions of the experimental points from the smoothed values are somewhat larger than would be anticipated from the precision obtained in the establishment of the primary variables, but probably this results from unsteady flow within the apparatus. Values of the Joule-Thomson coefficients at even values of pressure and temperature are recorded in parts of Table 2. It is probable that the recorded values do not involve uncertainties larger than 2 per cent.

TABLE 2.—*Joule-Thomson Coefficient and Isobaric Heat Capacity*

Pressure, Lb. per Sq. In. Absolute	70°F.		130°F.		190°F.		250°F.		310°F.	
	μ	C_P	μ	C_P	μ	C_P	μ	C_P	μ	C_P
FOR NATURAL GAS A										
0	0.0680[a]	0.4854[b]	0.0549	0.5078	0.0436	0.5328	0.0346	0.5607	0.0273	0.5890
200	0.0697	0.5048	0.0567	0.5242	0.0458	0.5472	0.0364	0.5735	0.0284	0.6004
400	0.0701	0.5250	0.0575	0.5412	0.0464	0.5622	0.0367	0.5873	0.0287	0.6128
500	0.0698	0.5353	0.0575	0.5501	0.0461	0.5700	0.0365	0.5943	0.0286	0.6192
FOR NATURAL GAS B										
0	0.0654[a]	0.4878[b]	0.0528	0.5092	0.0417	0.5332	0.0331	0.5600	0.0258	0.5871
200	0.0659	0.5070	0.0531	0.5258	0.0423	0.5472	0.0335	0.5722	0.0263	0.5977
400	0.0659	0.5280	0.0528	0.5434	0.0419	0.5618	0.0333	0.5846	0.0263	0.6087
600	0.0655	0.5520	0.0517	0.5632	0.0407	0.5772	0.0326	0.5970	0.0261	0.6195

[a] μ expressed as deg. F. per lb. per sq. in.
[b] C_P expressed as B.t.u. per lb. per deg. F.

CALCULATED RESULTS

The heat capacity of a natural gas at infinite volume may be computed from an assumption of ideal solution behavior without added uncertainty. Published data relating to the heat capacity of methane,[10] ethane,[4,7] propane,[9] n-butane,[9] isobutane,[9] n-pentane[9] and carbon dioxide[5] were employed to calculate the heat capacities of the two natural gases at infinite volume for temperatures between 70° and 310°F. These values are recorded at zero pressure in parts of Table 2. The progressive graphical solution of the following partial differential equation was utilized to determine the isobaric heat capacities at the higher pressures.

$$\left(\frac{\partial C_P}{\partial P}\right)_T = -\left(\frac{\partial \mu C_P}{\partial T}\right)_P \qquad [1]$$

It is believed that the heat capacities at the elevated pressures recorded in Table 2 involve uncertainties not more than 0.05 per cent larger than those associated with the data at zero pressure.

From the Joule-Thomson coefficients and the heat capacities recorded in Table 2, the enthalpy of each of the gases has been computed by suitable graphical integration of the expression

$$H = \int_{60}^{t} C_P^* \, dt - \int^{P} \mu C_P dP \qquad [2]$$

The results of this integration, based upon a datum value of zero at 60°F. and infinite volume, are recorded in parts of Table 3. Methods of correlating the isothermal changes in the enthalpy of pure substances which are based upon the law of corresponding states have been proposed.[3,11] These may be expanded so as to apply to multicomponent mixtures by application of the pseudocritical concept of Kay.[6] Such methods have been proposed by Brown[2] and have been utilized elsewhere.[8] Furthermore, the enthalpy of multicomponent gaseous hydrocarbon systems has been estimated[8] from the partial enthalpies of the components determined from the behavior of binary hydrocarbon mixtures. Values for the enthalpy of these two natural gases calculated from the values presented by Brown[2] are recorded in parts of Table 3. In addition, isothermal changes in enthalpy were predicted from the correlation of York and Weber[11] by the use of the pseudocritical concept. The isobaric changes in enthalpy with temperature at infinite volume used in this calculation were based upon the primary heat-capacity data utilized earlier in this discussion. The enthalpies of the natural gases have also been calculated from such of the partial enthalpies of the components as are at present available.[8] In general, the agreement between the several values is within approximately 3 B.t.u. per pound. However, the partial enthalpy approach apparently yields better values of the enthalpy with respect to temperature

TABLE 3.—*Comparison of Observed and Calculated Enthalpies*

Pressure, Lb. per Sq. In., Absolute	For Natural Gas A				For Natural Gas B			
	Experimental	Brown	York and Weber	Partial Enthalpies	Experimental	Brown	York and Weber	Partial Enthalpies
	70°F.				70°F.			
0 200 400 600	4.8[a] − 2.0 − 9.2 −16.7	5.0 − 0.5 − 8.3 −16.4	4.8[b] − 2.4 − 9.6 −16.8	4.8 − 2.5 −10.2 −18.1	4.9[a] − 1.7 − 8.5 −15.6	5.1 − 0.5 − 7.6 −15.8	4.9[b] − 1.6 − 8.2 −14.9	
	130°F.				130°F.			
0 200 400 600	34.6 28.9 22.8 16.4	34.8 29.0 23.5 18.6	34.6 29.0 23.3 17.7	34.6 30.0 22.8 14.9	34.8 29.3 23.6 17.8	35.3 30.0 25.3 20.0	34.8 29.5 24.2 18.9	34.7 30.2 22.3 13.6
	190°F.				190°F.			
0 200 400 600	65.8 61.0 55.8 50.6	66.5 60.8 57.3 52.5	65.8 61.0 56.4 51.8	65.8 61.6 56.1 51.1	66.0 61.5 56.8 52.2	67.4 62.2 58.3 53.5	66.0 61.7 57.2 53.2	65.9 61.8 55.4 50.0
	250°F.				250°F.			
0 200 400 600	98.6 94.6 90.3 86.0	99.0 93.4 90.3 85.4	98.6 94.6 90.8 87.0	98.6 95.3 91.1 87.1	98.8 95.0 91.2 87.3	100.3 95.4 91.1 87.6	98.8 95.1 91.4 87.8	98.8 95.7 90.9 86.8
	310°F.				310°F.			
0 200 400 600	133.1 129.8 126.3 122.8	133.0 128.0 125.0 121.2			133.2 130.1 127.0 123.8	134.7 129.7 127.4 124.7		

[a] Enthalpies expressed as B.t.u. per lb. and based upon a datum of zero at 60°F. and infinite volume. Enthalpies at infinite volume are based upon experimental heat capacities for the components.

at low pressures than are obtained from the more generalized approach. These comparisons indicate that at pressures below 600 lb. per sq. in. the methods of prediction currently available may be employed with some confidence. The presence of significant quantities of carbon dioxide in natural gas B rendered the application of partial enthalpy concept somewhat less certain than it would be if this gas were not present. This added uncertainty results from a lack of information concerning the partial enthalpy of carbon dioxide.

ACKNOWLEDGMENT

This work constitutes a part of the activities of Research Project No. 37 of the American Petroleum Institute, and has been made possible by cooperation and financial support from that organization. L. Fay Prescott assisted materially in the calculations.

NOMENCLATURE

C_P, isobaric heat capacity, B.t.u. per pound per degree F.

C_P^*, isobaric heat capacity at infinite volume, B.t.u. per pound per degree F.

H, enthalpy, B.t.u. per pound.

T, thermodynamic temperature, deg. R. (deg. F. abs.).

t, Temperature, deg. F.

μ, Joule-Thomson coefficient, deg. F. per pound per square inch.

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The Nature of Hastings Drilling Mud by Supercentrifuge and X-ray Analysis

BY GEORGE H. FANCHER* AND S. C. OLIPHANT†

ABSTRACT

Two samples of drilling mud from the Hastings oil field, Texas, were tested, and the solids in each were separated into small fractions of a limited range in particle size. The mineral composition of each fraction by X-ray analysis is reported, and the results are interpreted in relation to other measured quantities, such as the physical properties of the original samples and the density of the various fractions. It was found that only 7 to 8 per cent by weight of the solids was of colloidal dimensions and that neither of the samples contained montmorillonite but did contain illite. Considerable calcite was also found. These data should be useful to the geologist interested in the origin and history of sedimentary strata as well as to the petroleum engineer.

INTRODUCTION

The questions, What is good drilling mud? What constitutes bad drilling mud? are pertinent, because the proper use and control of drilling fluids has been a factor of great importance in the successful drilling and completion of oil wells since the days of Captain Lucas. Adequate control of the characteristics of drilling fluids has assumed greater significance comparatively recently because of the problems introduced by caving formations in deep wells, costly blowouts and impressive mud bills. Much is known about the solution of some of the problems but, despite extensive research directed toward a better understanding of the physical and chemical properties of clay suspensions, it is difficult to define precisely a drilling mud, and much more difficult to say what constitutes a good mud.

It is generally believed that the smaller particles of a drilling mud greatly affect its physical properties. In fact, it is customary to blame the colloids in a mud for nearly everything that goes amiss, because colloidal properties have effects out of all usual proportion on viscosity, filtration rate and reaction to electrolytes. It is germane to know whether drilling muds possess colloids and if so, the quantity and kind.

SOURCE OF SAMPLES

Two drilling muds from the Hastings oil field, Brazoria County, Texas, were selected because it is generally agreed that in this oil field good natural muds made solely from formations penetrated by the drill can be used until the well is nearly ready for completion. Customary drilling procedure in this field is to spud in with water, set a protective string of pipe, drill to 2500 ft. and set the surface casing. Drilling is continued to 5500 ft. with no treatment of the drilling fluid other than addition of water to

TABLE 1.—*General Geologic Log, Hastings Oil Field, Texas*

Depth, Ft.[a]		Zone
From	To	
4,800	5,200	Basal Miocene (Big Sand)
5,200	5,300	Top of Oligocene shale
5,300	5,650	Discorbis restricted (Meyer)
5,650		Heterostegina

[a] Exact depth subject to position on structure.

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maintain the concentration of solids and the viscosity at adequately low values. The mud begins to thicken below 5500 ft., and only slight chemical treatment is necessary to keep the viscosity low enough for good circulation.

The general geological type log for this field is presented in Table 1.

The characteristics of the samples of mud (50 gal. of each mud) that were obtained from Hastings prior to the addition of treating chemicals for the study of distribution of particle size are listed in Table 2.

The measurements of the viscosity and filtration rate of the samples in the field do not agree with those measured in the laboratory, but the latter were taken several months later and the difference may be due to the more vigorous stirring with the electric stirrer in the laboratory and to the increased hydration of particles. The Edwards mud represents the total accumulation in the drilling fluid from the grass roots to the basal Miocene, the Curkeet mud from the grass roots into the Oligocene shale. It is to be noticed that although the

TABLE 2.—*Characteristics of Untreated Hastings Mud*

Property	Edwards Mud		Curkeet Mud	
	Field	Laboratory[a]	Field	Laboratory[a]
Date	10/26/39		10/30/40	
Depth, ft	5,039		5,700	
Density, lb. per gal	9.8	9.9	9.8	9.8
Filtration rate, c.c. per 30 min	22.3	20.5	22.8	18.3
Viscosity (A.P.I.), sec		36	60	39
Viscosity (Stormer), centipoises		13		14.5
pH (mud)	8.5	8.8	8.9	
Salt (chlorides), per cent	0.19	0.165	0.12	
Solids, wt. per cent		21.88		23.0

[a] Mud stirred (electrically driven stirrer) to minimum viscosity.

TABLE 3.—*Procedure Index for Fractionation of Edwards Mud*

Fraction	Particle Diameter, Microns		Method of Separation and Classification According to Particle Size		
	Maximum	Minimum			
1–11		44	Original mud diluted to 2 per cent solids and allowed to stand one hour, after which time settlings were removed, dried, and classified with U. S. Standard screens.		
A	50	1	Material that passed through 325-mesh screen	Classification by Stokes' law using a submerged weighing pan	
11–25 B	20	3	Material from above remaining suspension after 12-hr. settling		
C	30	1	Material from above remaining suspension after 75-hr. settling		
			Supercentrifuge		
			Centrifuge Used, Inches Diameter	Speed of Bowl, R.P.M.	Rate of Feed of Suspension, C.C. per Min.
26	3.0	0.48	4	10,000	1,700
27	0.48	0.36	4	10,000	1,050
28	0.36	0.21	4	10,000	350
29	0.21	0.15	1¾	35,000	800
30	0.15	0.09	1¾	35,000	300
31	0.09	0.055	1¾	45,000	210
32	0.055	0.025	1¾	50,000	50

percentage of solids differs appreciably in the two samples, the densities are the same.

TREATMENT OF SAMPLES IN THE LABORATORY

After thorough mixing the muds were separated according to the schemes indicated by Table 3 and Fig. 1. The three methods of screen classification, sedimentation and centrifuging were employed to eliminate successively smaller particles in fractions. Standard Tyler-series screens were used for the larger particles (larger than 44 microns), the sedimentation method of Odem[9] and Tickell[10] for smaller particles (44 to 1.0 microns), and the Sharples supercentrifuge method of Hauser and Reed[7] and Norton and Speil[8] for the smallest particles. The Sharples centrifuge was calibrated and controlled by the method recently described by Fancher, Oliphant and Houssiere.[3] A material balance was kept, which showed 11.72 per cent loss of solids for the Edwards mud and 12.00 per cent loss for the Curkeet mud. The experimental error is large but it represents the unavoidable accumulative effect of the large number of transfers that were made of the materials. It has been assumed that the loss is constant for each fraction and the total loss has been distributed by multiplying the percentage of each fraction found by an appropriate factor (1.133 for Edwards mud).

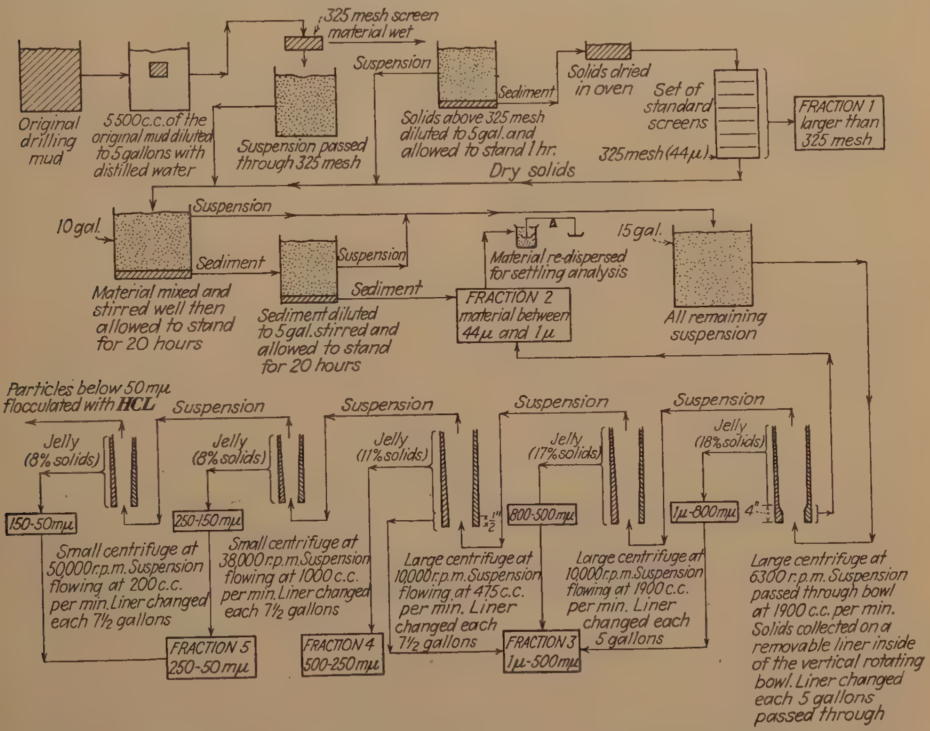
325 mesh screen
material wet
Suspension
Sediment
Solids dried in oven
Set of standard screens
FRACTION 1 larger than 325 mesh
Original drilling mud
5500c.c. of the original mud diluted to 5 gallons with distilled water
Suspension passed through 325 mesh
Solids above 325 mesh diluted to 5 gal. and allowed to stand 1 hr.
325 mesh (44μ)
Dry solids
10 gal.
Suspension
Sediment
Suspension
Sediment
15 gal.
Material re-dispersed for settling analysis
FRACTION 2 material between 44μ and 1μ
Material mixed and stirred well then allowed to stand for 20 hours
Sediment diluted to 5 gal. stirred and allowed to stand for 20 hours
All remaining suspension
Particles below 50mμ flocculated with HCL
Suspension
Suspension
Suspension
Suspension
Jelly (8% solids)
Jelly (8% solids)
Jelly (11% solids)
Jelly (17% solids)
Jelly (18% solids)
150-50mμ
250-150mμ
1 1/2"
800-500mμ
1μ-800mμ
4"
Small centrifuge at 50,000 r.p.m. Suspension flowing at 200 c.c. per min. Liner changed each 7½ gallons
Small centrifuge at 38,000 r.p.m. Suspension flowing at 1000 c.c. per min. Liner changed each 7½ gallons
Large centrifuge at 10,000 r.p.m. Suspension flowing at 475 c.c. per min. Liner changed each 7½ gallons
Large centrifuge at 10,000 r.p.m. Suspension flowing at 1900 c.c. per min. Liner changed each 5 gallons
Large centrifuge at 6300 r.p.m. Suspension passed through bowl at 1900 c.c. per min. Solids collected on a removable liner inside of the vertical rotating bowl. Liner changed each 5 gallons passed through
FRACTION 5 250-50mμ
FRACTION 4 500-250mμ
FRACTION 3 1μ-500mμ

FIG. 1.—SCHEME OF SEPARATION AND FLOWSHEET OF FRACTIONS FOR CURKEET MUD.

Perhaps the only significant details regarding the tedious fractionation that need be mentioned are the necessity to disperse agglomerated particles, the prevention of reagglomeration, the necessity to work with great dilutions and the rerunning of tailings until separation of the desired size fraction is achieved. For example, 2.448 grams of sodium hexametaphosphate were added to a suspension of 312 grams of solids in 10 gal. of distilled water to separate agglomerated particles, followed by 0.3 gram of Daxad (a salt of a sulphonated petroleum ester) to develop a protective layer of ions around each particle and prevent further agglomeration.

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[9] References are at the end of the paper.

PARTICLE-SIZE COMPOSITION OF THE MUDS

The results of the fractionation are given in Tables 4 and 5. The agreement between the size calculated from the conditions of separation and the size measured by direct examination with the slit-ultramicroscope is good. Fewer fractions of greater range of particle size were prepared from the Curkeet mud because it was desired to have larger fractions available for recombination for further study. Fifty per cent of the total amount of solids in these muds was made up of particles smaller than 5 microns in diameter. These same data are portrayed in Figs. 2 and 3. The curves have been drawn through points of maximum diameter for each fraction, so that the ordinate could be

TABLE 4.—*Fractions Prepared from Edwards' Mud*

Fraction No.	U. S. Standard Screen Size	Particle Diameter, Microns: Calculated[a] Maximum	Calculated[a] Minimum	Observed,[b] Average	Percentage of Original Solids (Corrected)[c]: Each Fraction	Cumulative	Density of Sample, Grams per C.c.	Mineral Composition,[d] Per Cent of Each Fraction: Silica	Calcite	Feldspar	Illite
32		0.055	0.025		1.0557	1.0557	2.452				100
31		0.090	0.055	0.087	0.6431	1.6988	2.479				100
30		0.150	0.090	0.150	0.5658	2.2646	2.533				100
29		0.216	0.150	0.195	0.385	2.6496		5	5		90
28		0.366	0.216	0.166[e]	2.340	4.9896		15	5		90
27		0.480	0.366	0.300[e]	1.730	6.7196	2.533	15	10		75
26		3.0	0.480	0.680	36.755	43.4746	2.555	35	40		45
25		1			1.892	45.3666					
24		2	1		4.385	49.7516	2.596				
23		3	2		2.265	52.0166					
22		4	3		1.170	53.1866					
21		5	4		0.8573	54.0439					
20		6	5		1.2511	55.2950					
19		7	6		0.8516	56.1466	2.657				
18		8	7		1.2096	57.3562					
17		10	8		1.0098	58.3660					
16		20	10		3.8751	62.2411					
15		30	20		2.5556	64.7967	2.646				
14		40	30		2.367	67.1637					
13		50	40		0.6095	67.7732					
12			50		1.087	68.8602					
11	325	53	44	50	2.028	70.8882	2.635	80	10	10	
10	270	74	53	59	2.674	73.5622	2.628	75	10	15	
9	200	88	74	63	2.759	76.3212	2.623	80–85	S–10	10	
8	170	125	88	87	9.370	85.6912	2.627	85–90	5	5–10	
7	120	149	125	117	5.699	91.3902	2.627	90	5	5	
6	100	177	149	145	1.906	93.2962	2.628	90	5	5	
5	80	250	177	171	4.195	97.4912	2.637	90	5	5	
4	60	350	250	264	1.556	99.0412	2.630	85–90	5–10	5	
3	45	840	350		0.8441	99.8851	2.622	65	25–30		5–10[f]
2	20	1,190	840		0.0455	99.9308		35	40		25[f]
1	16		1,190		0.0697	100		20	65		15[f]

[a] Fractions 1 to 11, inclusive, obtained by screening. Fractions 12 to 25, inclusive, obtained by sedimentation. Fractions 26 to 32, inclusive, obtained by centrifuging.

[b] Microscopic observations.

[c] Corrected for a total loss during experimentation of 11.72 per cent in total solids, distributed equitably.

$$\text{Correction factor} = \frac{100 - 88.28}{100 - 11.72} + 1 = 1.133$$

[d] By X-ray analysis.

[e] Average particle size observed smaller than calculated minimum, possibly due to peptization of coagulated systems.

[f] Apparently some large flakes of clay which were not dispersed. Due to imperfect technique. Should be ignored.

read as the total percentage smaller than the corresponding diameter. Both curves show two distinct changes in the amount of material lying between definite particle sizes, and consequently the frequency curves of Figs. 4 and 5 have been prepared by determining the change in accumulative percentage (ΔP) with respect to the change in diameter (ΔD) and plotting the product of this function $\left(\frac{\Delta P}{\Delta D}\right)$ multiplied by ($2.3D$) against ($\log_{10} D$). This method of plotting results in a frequency curve on semilog paper, which not only shows the distribution of the various sizes of particles but also makes it possible to integrate the curves with the production of a linear ogive. In other words, the area between any two ordinates beneath the curve indicates the amount of material for the size range. The change in percentages with respect to diameter is constant for particles between 2 and 20 microns for Edwards mud. The relative abundance of particles between 0.5 and 10 microns diameter is noticeable for the Curkeet mud.

In reference to the particle-size distribution of the two muds, Tables 1 and 2 indicate that the Curkeet mud contains accumulations from 500 ft. of Oligocene shales that are not present in the Edwards mud. Other things being equal, since the Basal Miocene is sandstone and shale and the Upper Oligocene is shale, it would seem logical to expect the Edwards mud, obtained while drilling in the Miocene, to contain more sand and less shale than the Curkeet mud, which was obtained while drilling in the Oligocene. The Curkeet mud should contain some sand from the Big Sand section, although the relative amount would be reduced because of the dispersion of Oligocene shale. Table 6 aids in the demonstration of these facts.

These data also are well illustrated by the distribution curves in Figs. 4 and 5, and

TABLE 5.—*Fractions Prepared from Curkeet Mud*

Fraction No.	U. S. Standard Screen Size	Particle Diameter, Microns, Calculated		Percentage of Original Solids		Percentage of Solids Corrected[a]		Mineral Composition,[b] Per Cent of Each Fraction			
		Maximum	Minimum	Each Fraction	Cumulative	Each Fraction	Cumulative	Silica	Calcite	Feldspar	Illite
23		0.05	0.001	0.504	0.504	0.581	0.581				
22		0.135	0.05	0.407	0.912	0.462	1.043				
21		0.25	0.135	2.64	3.552	3.00	4.043				
20		0.5	0.25	3.54	7.092	4.023	8.066				
19		0.8	0.5	3.295	10.387	3.744	11.81				
18		1	0.8	10.92	21.307	12.408	24.218				
17		2	1	18.05	39.357	20.510	44.728				
16		4	2	10.00	49.357	11.363	56.091				
15		6	4	5.03	54.387	5.715	61.806				
14		8	6	2.305	56.692	2.619	64.425				
13		10	8	1.71	58.402	1.943	66.368				
12		20	10	6.84	65.242	7.772	74.140				
11		40	20	4.13	69.372	4.693	78.833				
10		44	40	0.747	70.119	0.849	79.682				
9	325	53	44	1.23	71.349	1.397	81.079				
8	270	65	53	0.085	71.434	0.096	81.175				
7	230	74	65	2.98	74.414	3.386	84.561				
6	200	125	74	4.73	79.144	5.375	89.936				75
5	120	149	125	3.693	82.837	4.193	94.129				100
4	100	177	149	0.462	83.299	0.525	94.654				100
3	80	250	177	3.022	86.321	3.434	98.088	25	10		65
2	60	350	250	0.690	87.011	0.784	98.872	35	20	5	40
1	45		350	0.993	88.004	1.128	100.0	80	5	5	10

[a] Corrected for a total loss during experimentation of 12.0 per cent in total solids distributed equitably.

$$\text{Correction factor} = \frac{100 - 88}{100 - 12} + 1 = 1.136.$$

[b] By X-ray analysis.

definitely prove Curkeet mud to contain less sand and much more shale than Edwards mud. Curkeet mud had a higher viscosity because of the greater concentration of particles just larger than one micron in diameter, and a lower filtration rate because of the presence of more fine-grained shale and the relative absence of a large amount of sand. The salt content (Table 2) of the two muds could not be a great influencing factor in determining differences in the physical properties of the

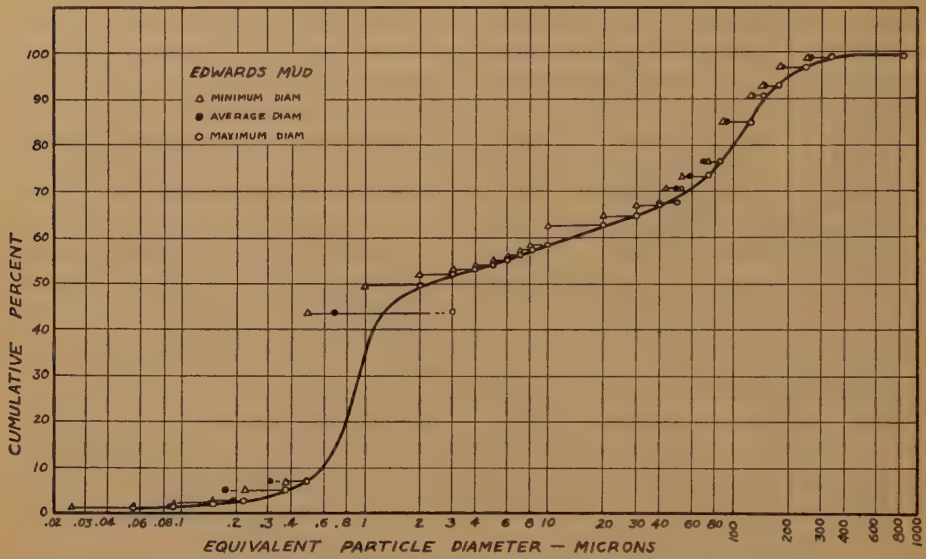

FIG. 2.—COMPOSITION OF EDWARDS MUD IN TERMS OF PARTICLE SIZE.

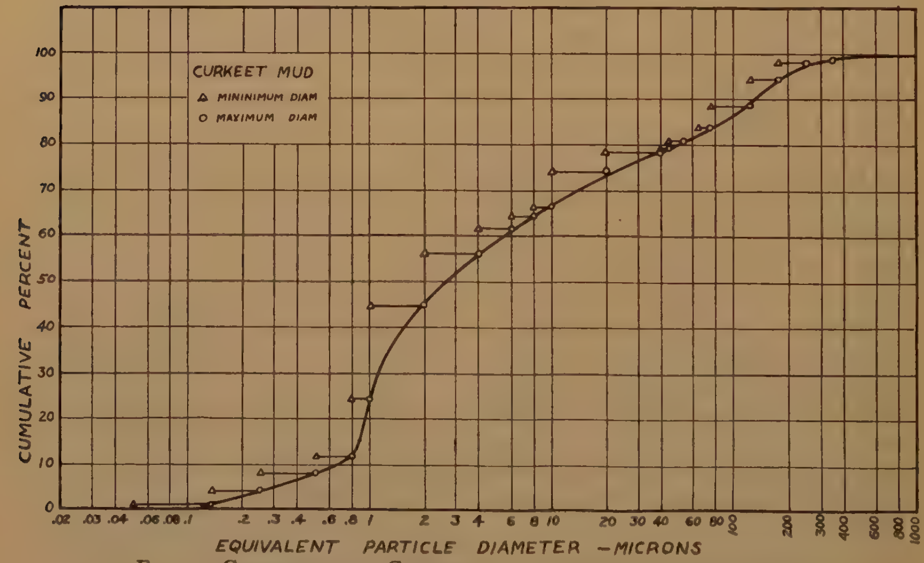

FIG. 3.—COMPOSITION OF CURKEET MUD IN TERMS OF PARTICLE SIZE.

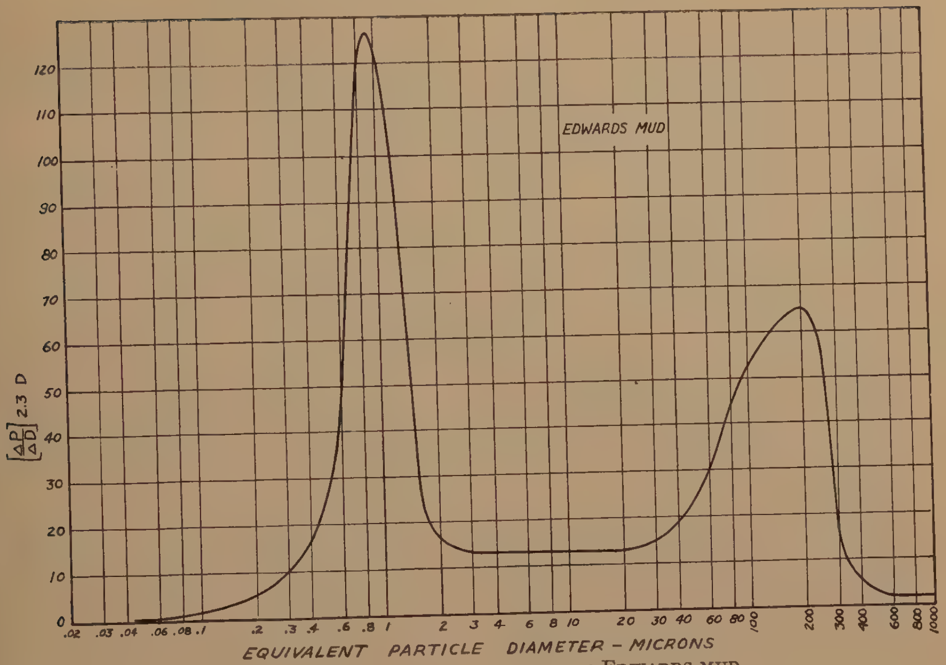

FIG. 4.—DISTRIBUTION OF PARTICLES IN EDWARDS MUD.

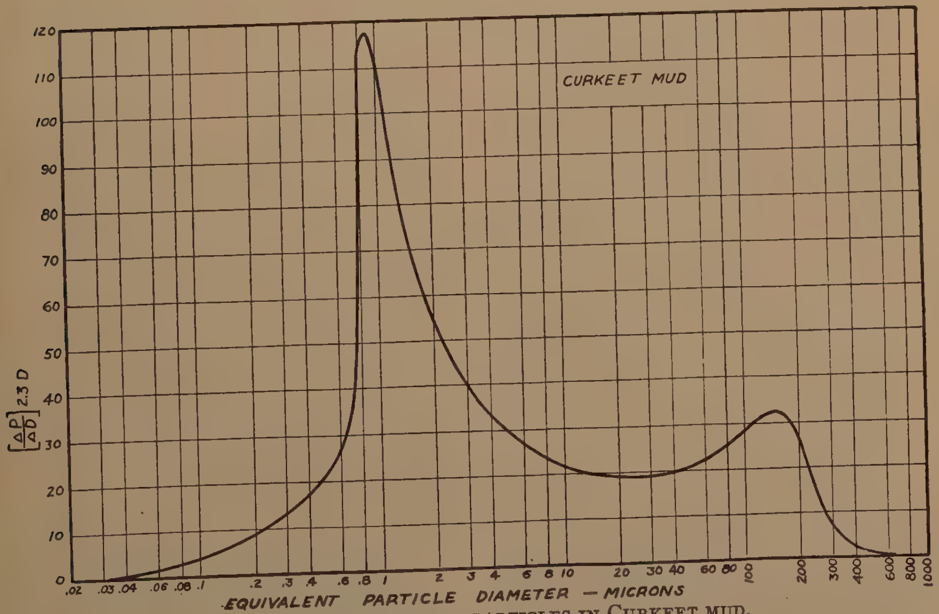

FIG. 5.—DISTRIBUTION OF PARTICLES IN CURKEET MUD.

two muds because the salt contents of the muds were similar.

Gates[4] recently studied the distribution of solids in a California drilling mud and found that 25 per cent was larger than 44 microns (325 mesh) in diameter, which agrees fairly well with Hastings mud. However, Gates found 25 per cent of the material to be between 44 and 6 microns (18 per cent for Curkeet mud and 12 per cent for Edwards mud) and an abundance of particles between 6 and 1 micron in diameter, and only 2 per cent smaller than one micron (Hastings mud 17 per cent).

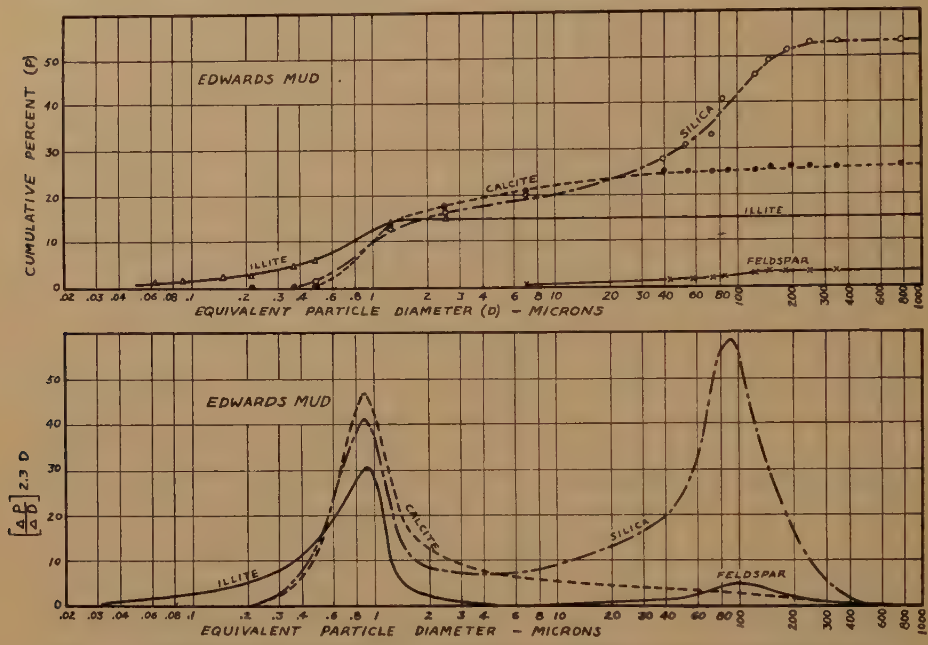

FIG. 6.—DISTRIBUTION OF MINERALS ACCORDING TO PARTICLE SIZE IN EDWARDS MUD.

TABLE 6.—*Solids in Mud*

Range in Diameter of Particles, Microns		Percentage of Total Solids	
From	To	Edwards	Curkeet
1,000	44	31	20
44	1	45	55
1	0.5	17	17
0.5		7	8

Burke[1] analyzed four California clays, determining the distribution of particles between 10 and 1 microns in diameter, with the results shown in Table 7.

Dunn[2] has investigated samples of the Miocene and Oligocene shales and found both to have the same amount of colloidal material for the sizes of particles studied, a result in harmony with the fact that Edwards mud and Curkeet muds have the same amounts of colloidal material.

TABLE 7.—*Composition of California Clays*

Source of Clay	Percentage of Solids	
	Below 1.0 Micron	Above 10.0 Microns
Kettleman Hills	0	90
Lorry Bend	10	50
Frazier Mountain	30	90
Wilmington slush	70	2

It should be realized that the distribution of particle size found by laboratory methods may not be an exact indication of the situation existing in drilling mud in the well. The mud in the well may contain many agglomerations of smaller particles. Grimm[5] says: "This study of a bentonite from Louisiana showed it to be composed of montmorillonite in particles that ranged up to 100 microns diameter. This clay is easily dispersed by simple agitation in water, so that all of it shows particles of 1 or less than 0.1 microns. Clearly, in making mechanical analysis of clays the measurement made represents the degree of disaggregation and frequently nothing else."

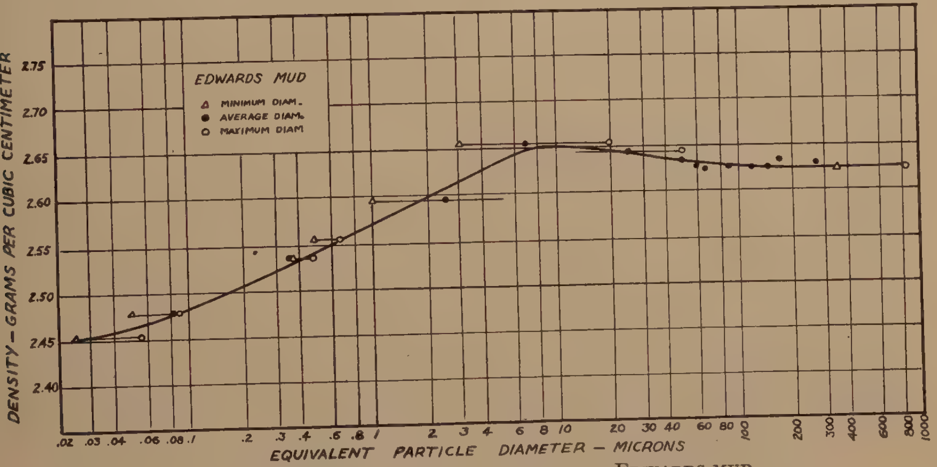

FIG. 7.—DENSITY OF VARIOUS PARTICLES IN EDWARDS MUD.

MINERAL COMPOSITION

The distribution of minerals in many of the fractions, as determined by the method of Hanawalt[6] through the courtesy of the Dow Chemical Co. (in its Research Laboratory at Midland, Mich.), provided the data presented in Fig. 7 and in Tables 4 and 5. The experimental error in X-ray analysis is between 5 and 10 per cent. These data may be compared with the analysis of the total solids in the original muds, by the same method shown in Table 8, and agree fairly well with the cumulative percentages found for each fraction (Tables 4 and 5).

According to Fig. 7, if the sand (defined by particle size alone) in the muds were eliminated, the greater part of the silica and feldspar would be eliminated from the mud. Comparison of the data in Table 8 shows that Edwards mud has a greater percentage of silica and feldspar and a smaller amount of illite and calcite than Curkeet mud. Neither mud contains montmorillonite.

TABLE 8.—*Mineral Composition of Original Mud Solids by X-ray Analysis*

Mineral	Formula	Percentage by Weight	
		Edwards Mud	Curkeet Mud
Silica	SiO_2	55	30
Calcite	$CaCO_3$	15	20
Feldspar	$(Na, K)Al\ Si_3O_8$	5	0
Illite	$(OH)_4\ K_y(Al_4, Fe_4, Mg_4, Mg_6)(Si_{8-y}Al_y)O_{20}$	25	50
Montmorillonite	$(OH)_nAl_4Si_8O_{20}$	0	0

These results are confirmed independently for Edwards mud by a measurement of the density of each fraction by a pycnometric method involving the use of water plus a surface-tension reducer for the larger particles and kerosene for the smaller particles. Fig. 7 shows that the larger particles ranged in density from 2.62 to 2.63 grams per cubic centimeter, whereas the particles 10 microns in diameter had a density of 2.65 grams per c.c. and particles smaller than 10 microns in diameter decreased uniformly to 2.45 grams per c.c. for the smallest particles tested. The bulk of the particles had a density of 2.6 grams per c.c. or greater. Table 9 shows the density of the minerals that are found in this mud as recorded in the literature.

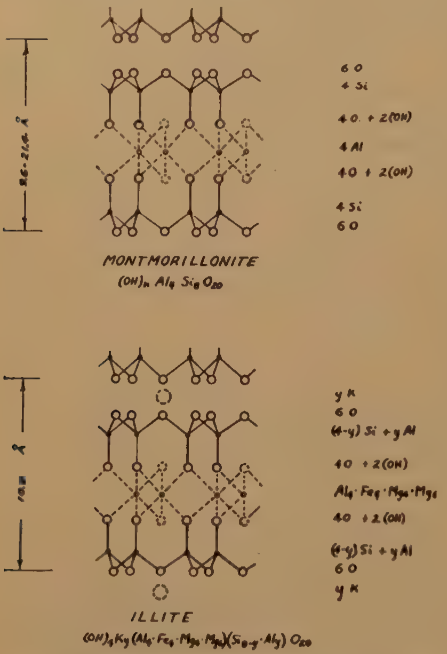
9.6-21.4 Å
6 O
4 Si
4 O + 2(OH)
4 Al
4 O + 2(OH)
4 Si
6 O
MONTMORILLONITE
$(OH)_4 Al_4 Si_8 O_{20}$
10 Å
y K
6 O
(4-y) Si + y Al
4 O + 2(OH)
$Al_4 \cdot Fe_4 \cdot Mg_4 \cdot Mg_6$
4 O + 2(OH)
(4-y) Si + y Al
6 O
y K
ILLITE
$(OH)_4 K_y (Al_4 \cdot Fe_4 \cdot Mg_4 \cdot Mg_6)(Si_{8-y} \cdot Al_y) O_{20}$

Fig. 8.—Crystal lattice patterns of clay minerals according to Grimm.

Table 9.—*Density of Minerals*

Mineral	Density, Grams per C.C.
Silica	2.65
Calcite	2.60–2.72
Feldspar	2.54–2.70
Illite	2.45

A decrease in density with particle size would seem to correspond to a decrease in calcite, silica and feldspar and an increase in illite. The density of the last fraction is 2.45 grams per c.c., which is that reported for illite. The X-ray work shows that the particles below 0.2 microns in diameter are composed chiefly of illite. The decrease in density with decreasing particle size is caused, therefore, by a change in minerals. It is clear, then, why the density of the unfractionated Curkeet mud with a greater percentage of solids was equal to that of the unfractionated Edwards mud (Table 2) rather than greater. Curkeet mud has a greater amount of smaller particles, and these smaller particles are minerals of lesser density. Silica particles are distributed over a wide range of particle sizes in these muds but are more abundant in larger size. Feldspar is found only among the larger particles.

Significance of Data

The source of the samples must be considered in an interpretation of these data. Edwards mud is rich in silica and feldspar because the sample was obtained while the well was drilling in sand beds. Curkeet mud contains less sand (particles larger than 44μ in diameter) and consequently less silica and feldspar. Edwards mud has the higher *proportion* of calcite (Tables 4 and 5) among the particles 2 microns in diameter. However, Curkeet mud has the greater *amount* of particles of this size. Consequently, the greater quantity of calcite actually found in Curkeet mud is in harmony with all the facts. The large amount of illite found in Curkeet mud is due, no doubt, to the Oligocene shales, which have been dispersed and which had not been penetrated in the Edwards well at the time the sample was obtained. Dunn[2] found the Oligocene shale to contain a mineral similar to, but different from, montmorillonite and it is suggested that this mineral is illite.

The high calcite content of these muds, as well as the wide distribution among particles from 1 to 40 microns in diameter, is interesting. Calcite is more abundant among the particles of 2 microns diameter. It is believed that few geologists or engineers concerned with Gulf Coastal formations have realized the quantity of calcite present in the formations. It is suggested that the calcite comes from thin lime streaks, since careful examination of drill logs and other well logs reveals the occurrence of lime streaks. Another possible explanation is precipitation of calcite from solution while drilling.

The presence of illite and absence of montmorillonite deserves further comment. Montmorillonite is a common constituent of argillaceous deposits in Texas and illite is known to occur in many formations. The clay minerals may be divided into four groups; namely, kaolinite, montmorillonite, illite (potash-bearing) and miscellaneous. All represent various stages of decomposition and alteration of sedimentary minerals. The kaolinite minerals, according to Twenhofel,[11] result from extensive leaching. Potash-bearing minerals resist leaching; consequently the result of very extensive leaching may be illite. The differences between illite and montmorillonite are significant and such as to merit attention. Fig. 8 shows a schematic drawing of the lattice patterns of the two minerals. Montmorillonite has a wider crystal and has no potassium between lattice layers. Grimm[5] has discussed these matters in detail.

Montmorillonite, while structurally similar to illite, has a greater surface area, absorbs more water, has a higher drying and shrinking value and a higher base-exchange capacity. Illite can absorb some water but usually swells very little because of the guardian potassium within the crystal lattice. The flakes of illite are larger than those of montmorillonite and therefore fewer are present per unit volume of clay. As a consequence, the plasticity of illite is much less than that of montmorillonite and so are the base-exchange properties. Illite appears to occur in most shales and exists as an intermediate in the eventual formation of kaolinite.

In view of the differences between illite and montmorillonite, it is possible that a mud containing colloidal material that is principally illite could very well have characteristics different from those of the mud containing montmorillonite. It is possible also that montmorillonite may change to illite in the presence of potassium ion, and, furthermore, it is probable that the reaction is not appreciably reversible. These facts may have to be kept in mind in studying the susceptibility of a mud to chemical treatment. Likewise, those interested in the origin of sediments and effects of subsequent geologic history on the present-day properties of particular sediments may find these results useful and significant. For example, in post-depositional changes in sediments, montmorillonite, in the presence of available potash salts, could be converted to illite. Possibly the conversion would not occur in fresh-water sediments but would in saline deposits because of the effect of pH on the process. It is known that the montmorillonite type of minerals is rarely dominant in geologically ancient sediments, except in bentonites, and these may have an entirely different origin. Illite is a prime constituent of many argillaceous sediments and undergoes alteration in any weathering process; therefore it is entirely within the bounds of reason and probability to suspect that the montmorillonite to illite conversion is a frequent one in sediments and that much illite is formed subsequent to deposition of the sediment.

SUMMARY

Two samples of a good natural drilling mud from the Hastings oil field were separated into fractions containing particles of a definite and restricted range in size.

The density, mineral composition and percentage relation of each fraction to the original sample were determined. It was found that only from 7 to 8 per cent by weight of the solids in the drilling muds was within generally accepted colloidal dimensions (0.5 micron equivalent diameter or less), although the amount of material between 0.5 and 1.0 micron was the same for each mud. The different distribution of particle size and density accounts for difference in percentage of total solids. The viscosity of Curkeet mud is higher than Edwards because of the higher concentration of solids and the greater number of shale particles slightly larger than one micron in diameter. Curkeet mud is lower in filtration rate because of the greater amount of shale and absence of sand. In view of the relatively small amount of material of colloidal dimensions found in these muds, it is suggested that the material larger than the colloidal range is quite as important as the colloids in determining the properties of mud and susceptibility to chemical treatment. Extensive leaching of the deposits forming this mud is suggested because of the occurrence of illite. The size and distribution of size, as well as the mineralogical constitution of sediments, should enable the sedimentary specialist to better understand the origin and history of a particular formation. It is realized that these findings are suggestive rather than conclusive and that much more work of similar character must be done before a good drilling mud can be defined in terms of particle size and mineral composition. Some results obtained in recombining the fractions that have been prepared in this work will be reported in a future paper.

ACKNOWLEDGMENT

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Response of a Gulf Coast Drilling Mud to Chemicals, Temperature and Heat-treatment

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Abstract

A typical drilling mud from the Hastings oil field, Brazoria County, Texas, containing only 8 per cent (dry basis) of material of colloidal dimensions, which is largely illite, was concentrated to a density of 10.2 lb. per gal. and used in this study. The effects of water dilution, treatment with complex polyphosphates, temperature and the time of heating upon the rheological properties of the mud were investigated. It was found that water plays an important part in chemical treatment and that sodium acid pyrophosphate and sodium tripolyphosphate were more efficient than other complex polyphosphates for chemical treatment. Muds treated with either of these chemicals manifested maximum reduction in viscosity and minimum filtration rates at low concentrations. Furthermore, mud treated to minimum viscosity with either of these two chemicals was virtually unaffected by heat-treatment.

Introduction

The drilling of deep wells is dependent upon the use of drilling mud, and problems frequently arise concerning the effects on mud of temperature, prolonged heating and aging. The use of chemicals to control the rheological properties of mud is a well-established practice. Salts of weak organic acids such as sodium tannate or gallate were used at first until the complex phosphates of sodium were found to be more efficient. Consequently, it seemed important to investigate the reaction of a mud to chemical treatment with phosphates, temperature, heat-treatment and aging, particularly since previous work in the laboratory at the University of Texas had provided the particle-size distribution and mineral composition of Hastings mud.

Properties of Mud Used in Experiments

A large sample of the mud from a drilling well in the Hastings field, Brazoria County, Texas, was obtained directly from the circulatory system. Some of the general physical characteristics of the mud and other data are presented in Table 1.

Table 1.—*General Properties of Hastings Drilling Mud*

	Alexander Well	Curkeet Well
Depth when sample was taken, ft.	5720	5700
Weight, lb. per gal.	9.5	9.8
Viscosity, sec. A.P.I.	47	60
Viscosity, Stormer, grams	80	
Viscosity, centipoises	13	
Filtration rate, c.c. per 30 min.[a]	19.6	22.8
Salt content (chlorides), per cent	0.13	0.12
pH	8.9	8.9

[a] Standard Test, A.P.I. Tentative Code No. 29.

The Alexander mud was used for the experimental work. Comparison with Curkeet mud indicates a considerably greater dilution but otherwise suggests similarity. The mineral composition and particle-size distribution of Curkeet mud (Table 2) are available (Fancher and Oliphant[5]). It is suggested that Alexander mud would have a similar composition.

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[5] References are at the end of the paper.

TABLE 2.—*Composition of Curkeet Mud*

Mineral	Percentage	Particle Diameter, Microns	Percentage
Silica	30	1000 – 44	20
Calcite	20	44 – 1	55
Feldspar	0	1 – 0.50	17
Illite	50	0.50 – Molecular	8
Montmorillonite	0		

PREPARATION OF SAMPLES

It is desirable to have a very viscous mud in order to study the effect of treating with chemicals over a suitable range of viscosity reduction. The Alexander mud directly from the field had a low viscosity (Table 1) so the 50-gal. sample was transferred to several large metal trays having a total surface area of 25 sq. ft. Electric fans were placed at each end of the trays and the air from the fans was directed upon the surface. A thin gel film formed periodically on the surface, so that intermittent stirring was necessary. In two days, 15 gal. of water were removed from the 50-gal. sample and the viscosity had been increased with minimum change in particle-size distribution and hydration of the particles. The thickened mud was well mixed by continuous pumping and circulation for 12 hr. to ensure uniformity when sampled.

Table 3 lists the physical properties of the thickened mud that was used for all the work reported in this paper, unless a dilution of this mud is stated.

TABLE 3.—*Physical Properties of Thickened Hastings Mud*

Weight, lb. per gal.	10.2
Filtration rate, c.c. per 30 min.[a]	14.3
Viscosity, sec. A.P.I.	63
Viscosity (Stormer), grams	140
Viscosity, centipoises	33
Initial gel strength, grams	115
10-minute gel strength, grams	197

[a] Standard Test, A.P.I. Tentative Code No. 29.

EXPERIMENTAL PROCEDURE

A standardized technique was developed for treating the various samples because it was found to be necessary in obtaining comparable results regarding the relative effectiveness of various chemicals. The mud was stored in 5-gal. glass bottles. Before any particular test, the mud in a bottle was stirred for 15 min., by the use of a large drill press equipped with a large propeller-type stirrer held in the chuck of the press and designed especially for this work.

A small portion was recovered from the bottle and the Stormer viscosity was measured after 2 min. of vigorous stirring with a small fountain stirrer (H.B. No. 18). If the Stormer viscosity was not 140 to 142 grams, distilled water was added until that viscosity was attained. The sample was then placed in a 1-qt. Mason jar, which was kept well sealed to prevent evaporation. This sample could be treated with a chemical, heat-treated and tested for viscosity, gel strength, pH and filtration rate.

A 100-c.c. sample is sufficient for the first three tests but standard A.P.I. procedure calls for 600 c.c. for the last. However, it was found that the same filtration rate was obtained when samples of 100, 200, 300, 400, 500 and 600 c.c. were used in the apparatus. The 300-c.c. sample was used for all filtration-rate tests. It was also found that minimum viscosity was attained within 2 min. when the 300-c.c. sample was stirred with the H.B. No. 18 fountain stirrer for samples having a viscosity in the neighborhood of 200 grams Stormer, and this time of stirring was adopted.

Gel strength was measured with the Stormer viscosimeter modified by a chainomatic weight device described by Keating.[9]

Viscosity, Chemical Treatment, and Other Analytical Tests

The Stormer viscosity of a 300-c.c. standard sample was measured and checked with the original sample. If it checked, a desired amount of 0.1 molar solution of a particular chemical was added to the mud, the latter was stirred for 2 min. with the H.B. stirrer and the Stormer viscosity measured as rapidly as possible. An additional amount of chemical was added and the procedure was repeated until at least nine treatments had been effected. These data form the basis of Table 4, and show the viscosity-reducing power of dilute solutions of the chemicals used. Similar data for chemical treatment with concentrated solutions (1.0 molar) are set forth in Table 5.

Check determinations were made in all cases. These data for each chemical have been plotted and a curve drawn to show variation of viscosity with chemical treatment over a wide range in concentration, but the curves are too numerous to reproduce here. At least 10 significant points on each viscosity curve were selected to represent a wide range of chemical treatment, including significant points such as minimum viscosity and the maximum viscosity obtained in overtreatment.

Samples (300 c.c.) of the standard mud were taken and treated with amounts of chemical corresponding to the selected points on the viscosity curves. These were stirred, the viscosity checked to be sure the correct reduction had been obtained, then the pH (Leeds and Northrup thin glass electrode) and the filtration rate were measured. The data so obtained regarding the variation of filtration rate and pH with chemical treatment are available in Tables 6 and 7.

TABLE 4.—*Viscosity of Hastings Mud upon Treatment with Tenth-molar Chemical Solutions*

Amount Added, C.C. per 300 C.C. Mud	Grams Stormer									
	(Na-$(PO_3)_6$	Na_6P_4-O_{13}	NaH_2-PO_4	$Na_4P_2O_7$	Na_2H_2-P_2O_7	Na_2-HPO_4	Na_5P_3-O_{10}	KNH_4-$H_4(PO_4)_2$	$(NH_4)_2$-HPO_4	$K_4P_2O_7$
0	140	140	140	140	140	140	140	140	140	140
0.1	128									
0.2	117	125	136	126	124	130	129	135	139	129
0.3	109									
0.4	105	112					122			
0.5	100		130	115	117	130		130	137	117
0.6		104					116			
0.7					112	129				109
0.8		97					110			
0.9										
1.0	83	93	125	100	108	126	103	126	131	107
1.5	70	80		89	101					98
2.0	64		119	80	95		87			88
2.5	63	75		73	87					79
3.0	63	67	115	68	82	115	75	114	122	72
3.5				64						
4.0		63	112	62	74		72			64
5.0	62		108	62	67	111	65	104	114	61
6.0		61								
7.0	61		103	61	62		64	102	109	61
8.0		60				106				
9.0										
10.0	61	60	100	61	60	104	62	98	107	60

Dilution with Water

The physical properties of a mud are changed by dilution with water. The effect of various amounts of distilled water added to 300 c.c. of mud upon viscosity, initial gel strength, 10-min. gel strength and filtration rate were determined. The results are listed in Table 8.

Temperature

Samples corresponding to each of the dilutions represented in Table 8 were used

TABLE 5.—*Viscosity of Hastings Mud upon Treatment with Molar Chemical Solutions*

Amount Added, C.C. per 300 C.C. Mud	Grams Stormer									
	(Na-PO$_3$)$_6$	Na$_6$P$_4$-O$_{13}$	NaH$_2$-PO$_4$	Na$_4$P$_2$O$_7$	Na$_2$H$_2$-P$_2$O$_7$	Na$_2$-HPO$_4$	Na$_5$P$_3$-O$_{10}$	KNH$_4$-H$_4$(PO$_4$)$_2$	(NH$_4$)$_2$-HPO$_4$	K$_4$P$_2$O$_7$
0	140	140	140	140	140	140	140	140	140	140
0.10	83	93	125	100	108	126	103	126	131	107
0.15	70	80		89	101					98
0.20	64	75	119	80	95		87			88
0.25	63				87					79
0.30	63	67	116	71	82	115	75	114	122	72
0.35										
0.40	63	63	112		74		72			67
0.45										
0.50	62	63	109	68	68	111	65	104	117	64
0.60										
0.70	61					109	64	102	115	62
1.00	61	62	105	68	64	107	62	100	113	62
2.00						109		102	114	
3.00	63	63	97	65	64	109	61	103	115	67
4.00								119	117	
4.50										
5.00	64	63	99	65	64	107	61		120	76
6.00									120	120
7.00				63			60			220
8.00									131	300
9.00									142	
10.00	67	66	104	62	64	103	60		153	
11.00									167	
12.00									183	
15.00	70	82	108	59	64	98	59			
20.00	78	108	110	60	64	95	59			
25.00	90	136	110	67	67		61			
30.00	107	162	111	75	69	105	65			
35.00	126	180	109	87	71		74			
40.00	147	177	110	107		118	80			
45.00	153	174	109	135	77		91			
50.00	154	168	108	145	79	140	102			

TABLE 6.—*Influence of Chemical Treatment with Molar Solutions upon Filtration Rate of Hastings Mud*

Amount Added, C.C. per 300 C.C. Mud	C.C. Water per 30 Min. at 100 Lb. per Sq. In.									
	(Na-PO$_3$)$_6$	Na$_6$P$_4$-O$_{13}$	NaH$_2$-PO$_4$	Na$_4$P$_2$O$_7$	Na$_2$H$_2$-P$_2$O$_7$	Na$_2$-HPO$_4$	Na$_5$P$_3$-O$_{10}$	KNH$_4$-H$_4$(PO$_4$)$_2$	(NH$_4$)$_2$-HPO$_4$	K$_4$P$_2$O$_7$
0	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.3
0.1		13.6		13.8						
0.2					12.8		13.4	13.8		
0.3										
0.4										
0.5		11.5		12.2	10.4					13.0
0.7										
1.0	10.3	10.5	13.1	10.5		13.4		13.1	14.1	11.9
2.0			12.1							
3.0	9.2		12.0	9.2	9.8	12.4	11.3	12.8	13.7	11.4
5.0	8.9	9.6			10.0	11.9	10.6	13.6	14.1	12.4
6.0			12.5							
7.0		9.5								
7.5										
8.0				9.0						
10.0	9.9				10.5	12.8	9.5	15.6	15.9	18.5
15.0	10.8	11.3	13.1	10.3		14.1	9.6	17.6	17.5	
20.0				10.8	10.5					
25.0	11.8	12.8					11.1			
30.0					10.8					
35.0	13.9	14.3	13.6	11.5	10.6	14.9	11.1			
40.0										
45.0										
50.0	14.9	18.7	13.6	13.7	11.2	15.7	12.6			

to investigate the effect of temperatures upon viscosity. The procedure was to place the stirred sample in the test cup of the Stormer viscosimeter, then put the viscosimeter in a small constant-temperature bath maintained at the desired temperature. A large weight was placed upon the pan of the machine and the sample was stirred continuously while rising to temperature, by movement of the cylindrical spindle controlled by alternate release and setting of the brake. The maximum time required to heat each sample to the particular temperature (10 min. for 185°F., for example) had been determined. After agitation for the time required, the viscosity was measured in the usual way. The viscosimeter had been calibrated with standard glycerol solutions for a range in viscosity of 1 to 108 centipoises.

TABLE 7.—*Effect of Chemical Treatment with Molar Solutions upon pH of Hastings Mud*

Amount Added, C.C. per 300 C.C. Mud	pH									
	$(NaPO_3)_6$	$Na_6P_4O_{13}$	NaH_2PO_4	$Na_4P_2O_7$	$Na_2H_2P_2O_7$	Na_2HPO_4	$Na_5P_3O_{10}$	$KNH_4H_4(PO_4)_2$	$(NH_4)_2HPO_4$	$K_4P_2O_7$
0	8.65	8.65	8.65	8.65	8.65	8.65	8.65	8.65	8.65	8.65
0.1	8.65	8.60								
0.2					8.52		8.70	8.50		
0.5		8.01		8.85	8.18					8.92
1.0	8.67	7.98	7.66	8.94		8.55		7.25	8.50	9.00
2.0			7.45							
3.0	8.70		7.15	9.10	7.12	8.30	9.00	6.55	8.26	9.20
5.0	8.75	6.63	6.75		6.82	8.01	9.03	6.50	7.85	9.35
7.5		6.42								
8.0				9.50						
10.0	8.83				6.27		9.20	5.98	7.65	9.73
15.0	8.90	6.35	6.23	9.60		7.98	9.25	5.57	7.50	
20.0					6.12					
25.0		6.27					9.30			
30.0					6.00					
35.0	8.95		5.73	9.65	6.02	7.92				
50.0	9.00	6.25	5.55	9.67	6.00	7.90	9.33			

TABLE 8.—*Effect of Dilution on Physical Properties of Hastings Mud*

Water Added, C.C. per 300 C.C. Mud	Weight of Mud, Lb. per Gal.		Viscosity		Filtration Rate, C.C.		Stormer Viscosimeter Gel Strength, Grams	
	Observed	Calculated	Stormer, Grams	Absolute Centipoises	Per 7.5 Min.	Per 30 Min.	Initial	10 Min.
0	10.2		140	32.5	7.5	14.0	115	197
5			131	29.5	7.2	14.5		
10			122	26.6	7.2	15.0	90	180
15			118	25.4	8.2	16.4		
25	10.05	10.05	113	23.7	8.5	16.5	76	153
35			104	21.3	8.5	17.0		
50	9.95	9.93	96	17.9	8.4	17.0	52	122
75	9.8	9.82	86	15.2	9.0	17.7	35	80
100	9.65	9.72	78	12.5	9.5	19.0	25	60
150	9.45	9.56	62	7.5		19.7	13	37
220						21.5		
300	9.15	9.24	47	3.5		23.0		

The constant-temperature bath was a 24 by 20 by 14-in. wooden tank lined with ⅛-in. galvanized iron. Heat was supplied by a 1000-watt heater connected through a thermoregulator and relay. Temperatures between 77° and 185°F.

could be maintained within ±0.5°F. The bath with the viscosimeter in position is shown in Fig. 1. The viscosimeter must be placed near the side to allow the weight to fall freely outside the bath.

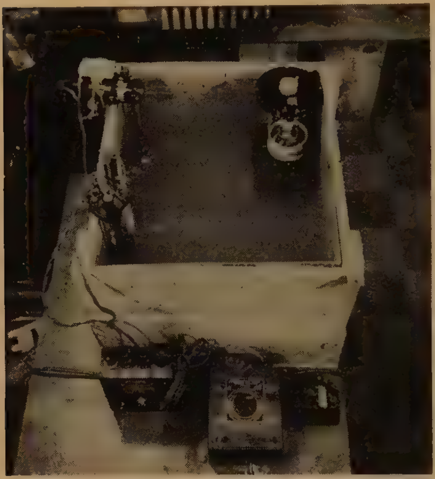

Fig. 1.—Viscosimeter in constant temperature bath.

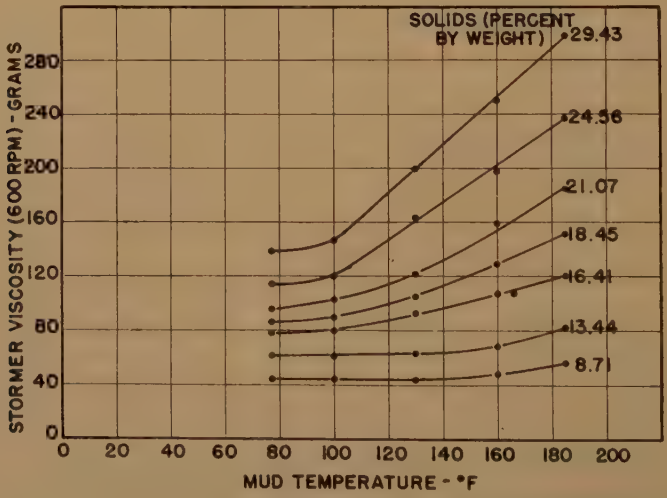

Fig. 2.—Effect of temperature on viscosity of Hastings mud.

Tests were conducted at temperatures of 77°, 100°, 130°, 160° and 185°F. The results are shown in Fig. 2.

Heat-treatment of Mud

The apparatus (Fig. 3) used for treating the samples with heat was designed to maintain constant temperature and continuous agitation of the samples under investigation. The apparatus consists of the following integral parts:

Constant-temperature Bath.—The bath is 42 in. long, 20 in. wide and 17 in. deep. It has a volume of 8.26 cu. ft. It is made of 2-in. pine boards but is lined with ⅛-in. galvanized iron. A cover was used during runs to reduce loss of heat and evaporation.

Temperature-control Unit.—The temperature-control unit consists of two heaters, one of 1250 watts and the other of 2500 watts. A variable control makes possible the use of any wattage between 220 and 3750.

Sample Holder and Driving Unit.—The sample holder consists of nine 1-qt. Mason jars held in place by composition rubber clamps around a central rotatable element. The two main bearing shafts of the holder were mounted on roller bearings and the holder was free to rotate about a horizontal axis. A 6-in. pulley for a V-belt attached to one end of one of the main bearing shafts permits rotation at 32 r.p.m. by a small electric motor operating through a small gear reduction unit.

Procedure.—Samples were placed in the quart Mason jars and stirred for 2 min. with the electric stirrer, capped and placed in the sample-holding device of the heat-treating bath and rotated for the required time at constant temperature. The viscosity was determined after 2, 5, 7, 9, 12, 24 and 36 hr. of heating at temperature of 77°, 100°, 130°, 160° and 180°F. When a sample was removed from a jar in the large bath, it was placed in a 250-c.c. bottle and tightly sealed and the bottle was put at once into the smaller bath, which was always kept at the temperature of the large bath. The bottles were agitated as vigorously as possible manually, a sample was quickly placed in the test cup of the Stormer viscosimeter and the viscosity was measured at the temperature of the heat-treatment. The sample was then removed from the bath, cooled to room temperature (77°F.) and stirred 2 min. with the H.B. stirrer, then the viscosity was measured. The data so obtained are shown in Figs. 4 and 5.

Samples were treated to the point of minimum viscosity using 1.0 molar solutions of the chemicals listed in Table 9.

These samples were handled according to the procedure just outlined and the viscosity was obtained after 4, 8, 12 and 24 hr. of heating at temperatures of 77°, 130° and 180°F. The results are shown in Tables 10 through 13 and the filtration rates of the various samples after 24-hr. heat-treatment are recorded in Table 14.

Discussion of Results

Effect of Dilution

The chief reason chemicals are used instead of water to control the rheological properties of drilling mud is that viscosity and gel strength can be controlled adequately without loss in weight, a point clearly demonstrated by comparison of data from Table 8 with Tables 4 and 5. For example, to obtain a viscosity of 62 grams Stormer, 150 c.c. of water must be added to a 300 c.c. sample of the standard mud, which results in a reduction in weight from 10.2 to 9.56 lb. per gal. The same reduction in viscosity can be obtained with any of the usual chemicals by the addition of approximately 1 c.c. of 1.0 molar solution to the sample with no loss in weight.

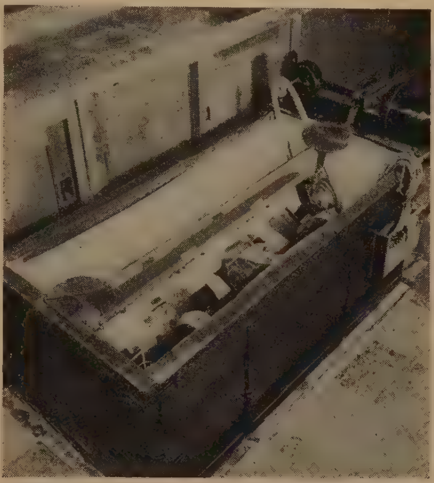

FIG. 3.—HEAT-TREATMENT APPARATUS.

If the data for the viscosity, initial and 10-min. gel strengths at various dilutions (Table 8) are plotted, all the curves have the same general shape, which suggests that a fundamental mechanism is involved when mud is diluted. It is believed that all of these properties decrease with increasing dilution because of the decrease in the ratio of the dispersed phase to the dispersion medium. Evaluation of the shape factor by Einstein's[4] equation using Tables 2 and 8 showed the particles to be platelike but to become more spherical upon addition of water.

The increase in filtration rate upon dilution (Table 8) is probably due to a disruption of the orientation and arrangement of the clay particles that were more completely developed in the more concentrated suspension. Perhaps some coagulation occurred also and the change in particle shape referred to is an important factor. These conclusions are in harmony with the most recent theories of the structure of colloidal particles and are particularly necessary to have in mind when considering the complex role played by water in the chemical treatment of mud.

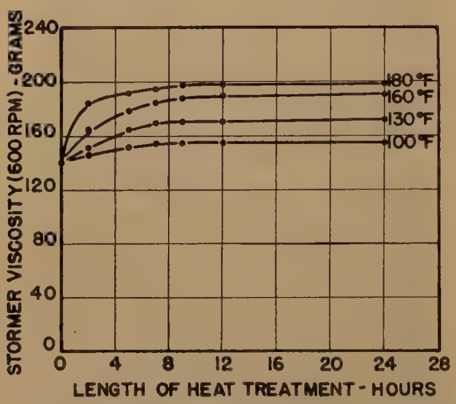

FIG. 4.—CHANGE IN VISCOSITY OF HASTINGS MUD FOLLOWING HEAT-TREATMENT AT ELEVATED TEMPERATURES.

TABLE 9.—*Amount of Chemical Solution Required for Maximum Reduction in Viscosity of Hastings Mud*

Compound	Formula	Molar Solution per 300 C.C. Mud, C.C.
Sodium tripolyphosphate	$Na_5P_3O_{10}$	20
Tetrasodium pyrophosphate	$Na_4P_2O_7$	18
Sodium acid pyrophosphate	$Na_2H_2P_2O_7$	10
Disodium phosphate	Na_2HPO_4	20
Monosodium phosphate	NaH_2PO_4	4
Tetrapotassium pyrophosphate	$K_4P_2O_7$	1
Diammonium phosphate	$(NH_4)_2HPO_4$	1
Potassium ammonium phosphate	$KNH_4H_4(PO_4)_2$	1
Sodium hexametaphosphate	$(NaPO_3)_6$	1
Sodium tetraphosphate	$Na_6P_4O_{13}$	1

Effect of Polyphosphates

A difficult problem in interpretation of the effects of chemical treatment of muds is the differentiation of the effect of the chemical from that of water. Chemicals may be added in bulk form and the dilution effect of the water of solution thus avoided. Because of the difficulty in knowing whether the chemical has dissolved completely in the mud (some of the complex polyphosphates are fairly insoluble in water), it is preferable to use solutions.

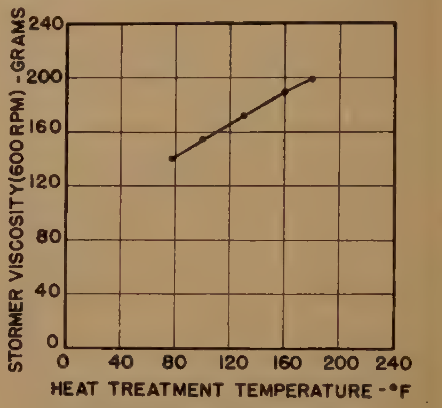

FIG. 5.—PERMANENT EFFECT OF HEATING ON VISCOSITY OF HASTINGS MUD.

TABLE 10.—*Viscosity of Chemically Treated Hastings Mud after Heating at 77°F.*

Compound[a]	Stormer Viscosity at 77°F., Grams			
Time of heating, hr.	4	8	12	24
$(NaPO_3)_6$	65	65	63	63
$Na_6P_4O_{13}$	68	65	63	63
NaH_2PO_4	97	102	102	102
$Na_4P_2O_7$	63	63	63	63
$Na_2H_2P_2O_7$	58	58	59	58
$KNH_4H_4(PO_4)_2$	110	109	109	109
$(NH_4)_2HPO_4$	117	117	117	117
$K_4P_2O_7$	65	67	70	72

[a] Sufficient chemical added to mud to produce minimum viscosity at 77°F. before heating.

The expression of concentration is another problem. Should this be in terms of a molar, molal, normal, constant-weight or constant-volume solution? The pros and cons for each need not be repeated. The molar system has been used in this work.

It was found that 1.0 molar solutions were satisfactory in investigating overtreatment but more dilute solutions (0.1 molar) were necessary to investigate reduction to minimum viscosity. The work of Loomis et al.[10] indicated that the effect of water dilution on rheological properties could be used to correct results obtained with standard chemical solutions to the dry chemical basis by simply subtracting the effect produced by simple water treatment from that of the solution. If this method were valid in this case, the same result should be obtained on the basis of the dry chemical for treatment with 0.1 molar solution as with 1.0 molar. Unfortunately, two distinctly different viscosity-reduction curves were obtained with each chemical tried, one for 0.1 molar and a different one for 1.0 molar. When this comparison was obtained, treatment with the dry chemicals in amounts equivalent to the solution was made. A third and distinctly different viscosity-reduction curve resulted.

TABLE 11.—*Viscosity of Chemically Treated Hastings Mud after Heating at 130°F.*

Compound[a]	Stormer Viscosity, Grams							
	At 130°F.				At 77°F.			
Time of heating, hr.	4	8	12	24	4	8	12	24
$(NaPO_3)_6$	95	105	113	120	65	67	69	69
$Na_6P_4O_{13}$	90	90	95	118	6	70	69	73
NaH_2PO_4	170	170	170	170	92	90	90	89
$Na_4P_2O_7$	61	62	65	78	58	58	59	59
$Na_2H_2P_2O_7$	71	71	71	72	58	58	59	59
Na_2HPO_4	137	150	150	160	85	85	82	82
$Na_5P_3O_{10}$	80	75	75	75	69	67	67	69
$KNH_4H_4(PO_4)_2$	190	195	195	202	108	108	108	108
$(NH_4)_2HPO_4$	172	185	190	200	120	124	120	120
$K_4P_2O_7$	94	111	125	141	64	70	80	91

[a] Sufficient chemical added to mud to produce minimum viscosity at 77°F. before heating.

TABLE 12.—*Viscosity of Chemically Treated Hastings Mud after Heating at 180°F.*

Compound[a]	Stormer Viscosity, Grams							
	At 180°F.				At 77°F.			
Time of heating, hr.	4	8	12	24	4	8	12	24
$(NaPO_3)_6$	145	150	145	145	73	80	86	86
$Na_6P_4O_{13}$	160	170	170	170	85	84	84	84
$Na_4P_2O_7$	75	75	75	77	77	80	77	77
$Na_2H_2P_2O_7$	95	93	93	93	64	69	69	69
$Na_5P_3O_{10}$	74	74	70	75	63	64	69	69
$K_4P_2O_7$	160	202	202	202	82	107	109	110

[a] Sufficient chemical added to mud to produce minimum viscosity at 77°F. before heating.

Likewise, all the different types of solutions mentioned previously were tried and results corrected for dilution and different curves found for all. The last experiment tried was to treat the standard mud with a small amount of chemical, then dilute and correct for the dilution to the dry basis, then add more chemical, dilute further and so on. Each time a different curve resulted and the only conclusion possible is that a very large number of water-dilution curves are possible, and the action of water is complex. Regarding this conclusion, it can be said that the viscosity-reduction curve obtained upon dilution is a function of the type and chemical nature of the aqueous chemical solution added, the viscosity at the time of chemical treatment, the original stability of the suspension and the mineral composition of the mud. It would also appear that an adequate formulation of the exact role played by the water and that by the chemical is needed.

TABLE 13.—*Viscosity of Chemically Treated Hastings Mud after 24 Hours Heat-treatment*

Compound[a]	Stormer Viscosity at 77°F., Grams		
Temperature of heating, deg. F.	77	130	180
$(NaPO_3)_6$	63	69	86
$Na_6P_4O_{13}$	63	73	84
NaH_2PO_4	102	89	
$Na_4P_2O_7$	63	69	77
$Na_2H_2P_2O_7$	58	59	59
Na_2HPO_4	94	82	
$Na_5P_3O_{10}$	63	69	69
$KNH_4H_4(PO_4)_2$	109	108	
$(NH_4)_2HPO_4$	117	120	
$K_4P_2O_7$	72	91	110

[a] Sufficient chemical added to mud to produce minimum viscosity at 77°F. before heating.

The standard mud used in these experiments has a high solids-to-water ratio. A considerable variation in particle size exists in the solids of the mud, ranging from submicroscopic to microscopic size. Approximately 8 per cent is of colloidal dimensions.

Illite is the chief clay constituent, no montmorillonite being present. Illite hydrates but does not swell in the presence of water, adsorbs ions and develops a water hull. Garrison[6] suggested, and Loomis, Ford and Fidiam[10] developed the idea, that viscosity-reducing chemicals are adsorbed on the surfaces of clay particles and reduce viscosity by reduction of the aggregation of particles into structures. Not only are ions adsorbed on the active surfaces of the clay particles but also a water envelope either develops or decreases in thickness owing to the hydration of the adsorbed cations. The relative nature and magnitude of these two forces determines the stability of a clay suspension. Both are active when chemicals are added to a mud. Because in most clay systems, and particularly in this one, there is a deficiency of negative ions, upon the addition of an electrolyte, negative ions are adsorbed until a maximum surface concentration is attained. Maximum reduction of viscosity due to chemical action occurs at this point. Upon further addition of electrolyte, positive ions are adsorbed in a layer, forming a solvated hull and eventually a monomolecular neutral layer. This condition is believed to be reached at the isoelectric point. Viscosity, therefore, increases from the minimum to a maximum at the isoelectric point. It was thought that the dissociation constants for the complex phosphates might be correlated with the experimental results and aid in the application of these theories to them, but extensive search of the literature and correspondence with research laboratories and manufacturers of these chemicals yielded no data or opinion other than the belief that the dissociation of the complex phosphates probably is complex.

It was observed that in all cases maximum reduction of viscosity was attained rapidly and was followed afterward upon further treatment by a region in which viscosity remained at a minimum value and changed slowly. Upon still further treatment, viscosity increased noticeably. Calculations similar to those made by Loomis[10] showed in all cases that minimum viscosity was obtained at maximum surface concentration of the chemical, using the particle-size data and mineral composition from Tables 2 and 4. At this point, further addition of electrolyte caused little change in viscosity, because of the dilution effect of the water in the solution, until the pronounced accumulation of positive ions in the solvated bulk caused viscosity to increase rapidly.

In particular, the polyphosphates studied can be divided into two groups (Tables 4 and 5). Minimum viscosity occurred at about 110 grams Stormer, for one group (the orthophosphates) and at about 60 grams Stormer for the other (the polyphosphates). All the compounds in the first group contain the PO_4 radical. Furthermore, as the number of PO_4 radicals per molecule increase, the reduction in viscosity increases. Here, again, knowledge of the dissociation of the complex phosphates could be utilized in interpretation of these phenomena. The amount of polyphosphate required for maximum reduction of viscosity varied from 0.15 to 0.25 grams per 300 c.c. of mud, which in all cases corresponded to 0.0010 mols, a result similar to those found by Loomis, Ford and Fidiam.[10]

Sodium hexametaphosphate produced the most rapid reduction in viscosity. Several of the other polyphosphates produced an equivalent minimum viscosity but larger quantities of chemical were required. The greatest reduction in viscosity was obtained with tripolyphosphate.

These data also suggest that there is some relation between the lowering of viscosity and the number of phosphorus atoms per molecule. As the complexity of the polyphosphate and the number of phosphorus atoms increases, reduction of viscosity increases. The positive ion is important because a greater reduction in viscosity was obtained with tetrapotassium pyrophosphate than with tetrasodium pyrophosphate. The data of Table 5 demonstrate for all of the phosphates that continued treatment results in overtreatment. Tetrapotassium pyrophosphate showed the greatest overtreatment and sodium acid pyrophosphate the least. Tripolyphosphate exhibited low overtreatment properties.

The observation of Loomis, Ford and Fidiam,[10] that with increasing molecular weight of the polyphosphates there was a corresponding increase in permanency of reduction of viscosity, was found not to apply to Hastings mud. In fact, sodium acid pyrophosphate produced the more permanent reduction in viscosity and showed the fewest characteristics of overtreatment, and the compounds containing the greatest number of sodium atoms produced the least permanent effect. The fact that the colloidal fraction of Hasting mud contains illite rather than montmorillonite should be considered in connection with these results.

Ammonium phosphates are not useful in actual mud-control practice, according to the experimental results. Neither of the compounds used exhibited properties of good viscosity reduction and both overtreated greatly at low concentration.

Two viscosity maxima were obtained with sodium tetraphosphate, tetrasodium phosphate, sodium hexametaphosphate and monosodium phosphate.

Data concerning viscosity change past the isoelectric point were obtained for sodium tetraphosphate. The results correspond to the reduction that would be obtained upon the addition of an equivalent volume of water. In other words, addition of chemical to an overtreated mud is useless; water will give the same results.

Loss of Water from Mud during Filtration

The results of the filtration experiments indicate that filtration rate is primarily a function of the permeability of the filter cake, which, of course, is related to the particle-size distribution and arrangement of particles. It is believed that a decrease in the viscosity of the suspension produces in all probability an improved orientation and arrangement of the particles, which results in a minimum filtration rate. Flocculation causes an increase in viscosity and an increase in filtration rate. In all cases, the filtration rate decreased upon slight chemical treatment and increased upon further treatment.

Minimum filtration rate was obtained with sodium hexametaphosphate and with tetrasodium pyrophosphate, although many of the compounds behaved nearly as well. Tripolyphosphate and sodium acid pyrophosphate, which show least tendency toward overtreatment in this region of concentration, both develop a mud of almost constant filtration rate. In mud-control practice, repeated treatment of mud frequently is necessary, causing considerable concentrations of chemicals in the mud.

In general, minimum filtration rates (Table 6) were obtained at points of maximum reduction of viscosity (Table 5). Disodium phosphate was an exception. It is believed that in this case maximum reduction of viscosity due to the adsorption of phosphate ions occurred when 5 c.c. of 0.10 molar reagent had been added and that the further reduction obtained during the addition of the next 15 c.c. of solution was largely a dilution effect. The pH was lowest at the 5 c.c. point and the filtration rate changed at this point.

Careful study of the data led to the belief that a relationship exists between the change in viscosity and the filtration rate, but no simple correlation could be developed. It is apparent that the viscosity change is a far more sensitive characteristic of mud properties than is filtration rate.

Hydrogen-ion Potential

The pH of the chemically treated muds tended to approach that of the chemical solution. The range in pH for the solutions used was 5.6 to 9.7. If the viscosity of the muds is plotted against pH, two minima are obtained at approximately $pH = 6 - 8$ and $pH = 8.7 - 9.6$. Loomis and coworkers[10] obtained similar results except that 5.5 and 11 were the pH values. Loomis's mud systems were entirely different from these, of course, and no relative significance is suggested.

Temperature

Apparently, the effect of temperature upon the viscosity of muds is dependent upon the relative magnitude of two operative and opposing forces, which are:

1. A normal decrease in the viscosity of the suspension because of the decrease in viscosity of water with increasing temperature.
2. A change that may be either an increase or a decrease in the viscosity of the suspensions due to the effect of temperature upon dispersed clay particles, which seems to be dependent upon the length of time that the sample is held at an elevated temperature. In general, a decrease in the viscosity of the mud occurred initially with an increase in temperature, followed by a marked increase in viscosity upon further increase in temperature. The standard mud, undiluted, showed an increase in viscosity only with increase in temperature, which possibly may be attributed to the unusually high solids-to-water ratio. This supposition is in harmony with the fact that as the solids-to-water ratio decreased, the point of minimum viscosity was shifted to a higher temperature. The mud having the lowest solids-to-water ratio exhibited minimum viscosity at 130°F., a result in harmony with the idea that two forces are operative. Hobson[8] arrived at a similar conclusion on the basis of limited data.

TABLE 14.—*Water Loss from Chemically Treated Hastings Mud*

Compound[a]	Filtration Rate, C.C. per 30 Minutes			
	Immediately after Chemical Treatment at 77°F.	After Heating for 24 Hr. at		
		77°F.	130°F.	180°F.
$(NaPO_3)_6$	10.4	10.5	10.5	10.4
$Na_6P_4O_{13}$	10.5	11.3	11.5	11.5
NaH_2PO_4	12.1	12.1	13.3	
$Na_4P_2O_7$	10.6	10.6		10.6
$Na_2H_2P_2O_7$	10.5	9.8	9.5	9.6
Na_2HPO_4	14.5	13.3	12.8	
$Na_5P_3O_{10}$	10.4	9.6	8.5	8.5
$KNH_4H_4(PO_4)_2$	13.1	13.1	13.3	
$(NH_4)_2HPO_4$	14.0	12.8	12.8	
$K_4P_2O_7$	11.9	12.3	12.4	12.3

[a] Sufficient chemical added to mud to produce minimum viscosity at 77°F. before heating.

Reports in Literature.—Investigations reported in the literature indicate that for all muds that have been tested between 60° and 200°F. viscosity decreased at first upon increase of temperature and then increased markedly at higher temperature. The temperature of minimum viscosity has been reported at various times to be between 115° and 185°F., dependent upon the nature of the mud.

It is difficult to compare with assurance the results in the literature with those reported here, because of the frequent confusion between temperature and heat-treatment at a temperature. With the exception of one investigator, all fail to describe or even mention procedure in obtaining data. It is not known, for example, whether evaporation was prevented or viscosity at the initial temperature was unchanged during a series of tests. Nevertheless, these results are somewhat similar to those reported in the literature, in that suspensions of greater dilution show a slight decrease in viscosity with increase in temperature up to 130°F., and thereafter, an increase. Few studies have been made for solids concentration greater than 15 per cent.

The very large decrease in viscosity with temperature reported by Byck,[1,2] Craft and Exner[3] and Routh and Craft[12] was not observed with any of the suspensions used in this study. It is believed that the muds used by these investigators probably contained montmorillonite, whereas the mud used in this study contained none, but did contain illite. It is suggestive that illite flakes are larger than those of montmorillonite, therefore fewer are present in a given volume of clay. Hence the total surface area in an illite clay is less than in a montmorillonite clay and the water films developed upon dispersion are fewer and thinner. Grim, Bray and Bradley[7] have developed dehydration curves for illite and Nutting[11] for montmorillonite. Approximately the same dehydration properties below 212°F. were found and the magnitude of dehydration was about 4 per cent in each case. These results, considered together with the thinner water hulls of illite, indicate a lesser decrease in viscosity for illite clays with temperature and a lower temperature for coagulation. However, the rate of increase in viscosity upon further increase in temperature at elevated temperature should not be as great for illite clays because montmorillonite shows a more rapid rate of water loss.

Heat-treatment Study

The rheological properties of the standard mud did not change at a temperature of 77°F. over a period of six months during the course of this study. This behavior would indicate complete hydration of the clay particles. The fact that the clay mineral of the mud is illite is also significant.

Heat-treatment at temperatures above 77°F. affected the viscosity of the mud markedly. In all cases, the viscosity increased with increase in temperature, and the magnitude of increase was dependent upon the time the sample remained at the elevated temperature until a maximum viscosity was attained. Seven to ten hours of heating were required for development of maximum viscosity. Furthermore, the maximum viscosity obtained varied linearly with the temperature of heat-treatment, except for a tendency to flatten near the highest temperature attained. It was not possible to study the effects at 200°F. because of insufficient sample but Hobson[8] has shown that for several clays maximum viscosity was attained between 160° to 175°F., after which viscosity decreased. He also found 6 to 10 hr. were required for development of maximum viscosity.

The permanency of the viscosity change was investigated by cooling to room temperature after heat-treatment and measurement of the viscosity. Permanent change in viscosity due to heat-treatment was found in all cases. These results were checked by remeasurement of the viscosity of all heat-treated samples a month after treatment. The viscosity checked that obtained immediately after cooling of the sample from the temperature of heat-treatment to 77°F. Furthermore, the maximum temperature attained is the criterion of the permanent change in rheological properties because the samples could be heated and cooled repeatedly without affecting the properties as long as the reversal temperature was less than that of heat-treatment.

The heat-treatment of muds chemically treated to minimum viscosity (Table 13) showed the viscosity of all samples to remain constant after heat-treatment for 24 hr. Whether the viscosity increased, decreased or remained constant depended on the chemical used and the temperature of heat-treatment. The tests at 77°F. show the effect of aging whereas the tests at 130° and 180°F. are indicative of the stability and permanence of the viscosity reduction produced by the various chemicals.

Mud treated with sodium acid pyrophosphate showed no variation of viscosity with heat-treatment. Mud treated with tripolyphosphate also exhibited desirable resistance to heat-treatment. However, the viscosity of most of the chemically treated muds increased with the temperature of heat-treatment. In these cases, great gel strength was developed by the heat-treatment, especially with tetrapotassium pyrophosphate.

CONCLUSIONS

1. Dilution of Hastings mud results in lowering the viscosity and gel strength and increase in the filtration rate.

2. The polyphosphates as a group caused greater reduction in the viscosity of Hastings mud than the orthophosphates. In particular, sodium acid pyrophosphate and sodium tripolyphosphate are more effective than the other complex polyphosphates in reduction of the viscosity of Hastings mud containing illite as the chief clay mineral.

3. The number of mols of polyphosphate required for a maximum reduction in the viscosity of Hastings mud caused solely by surface adsorption of the chemical is independent of the particular polyphosphate used (see Tables 4 and 5).

4. Hastings mud treated with either sodium acid pyrophosphate or sodium tripolyphosphate exhibits fewer characteristics of overtreatment.

5. Hastings mud treated with either sodium hexametaphosphate or tetrasodium pyrophosphate has lower filtration rates than mud treated with other complex polyphosphates (see Table 6).

6. Filtration rates for Hastings mud treated with either sodium acid pyrophosphate or sodium tripolyphosphate become nearly constant at high concentration.

7. When Hastings mud is treated with a polyphosphate, usually minimum filtration rate is obtained at the point of minimum viscosity.

8. The curve showing the relation between pH of chemically treated mud and viscosity exhibits two minima and illustrates two ranges of flocculation, one of deflocculation and the condition of the clay suspension at the isoelectric point.

9. The variation of the viscosity of a mud with temperature is believed to depend upon the relative magnitude of (*a*) the viscosity-temperature variation of water, (*b*) the effect of temperature on the dispersed phase (clay) of the mud. The latter depends on the length of time the mud is held at an elevated temperature.

10. The temperature at which viscosity of a mud is minimum varies inversely as the solids to water ratio.

11. The changes in a mud that result in changes in rheological properties upon heating are permanent and depend upon the time of heating until a maximum change results. Maximum viscosity was obtained in from 7 to 10 hr. of heating.

12. Heating of chemically treated muds results in impairment of the rheological properties except sodium acid pyrophosphate and sodium tripolyphosphate, which are only slightly affected.

13. Sodium acid pyrophosphate and sodium tripolyphosphate were found to be more efficient than other polyphosphates for treating Hastings mud from all points of view.

14. Hastings mud was found to be very stable. When completely hydrated, no changes in rheological properties were found over a period of six months.

15. Ammonium polyphosphates are believed to be unsatisfactory in mud-control practice on the basis of the two compounds studied. Neither compound possessed good viscosity-reduction properties and each overtreated greatly at low concentration.

16. Tetrapotassium pyrophosphate is not satisfactory for the treatment of Hastings mud. It possesses no superiority with respect to viscosity reduction, and overtreats at low concentration to a greater degree than any of the other compounds used.

ACKNOWLEDGEMENT

The assistance of the Stanolind Oil and Gas Co. in obtaining the mud from a drilling well in the Hastings field, and in other matters pertaining to the research, is gratefully acknowledged by the authors.

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Effects of Certain Gums and Starches on Filtration of Salt-water Muds at Elevated Temperatures

By Frank Perkins* and Benjamin C. Craft,† Member A.I.M.E.

(Austin Meeting, October 1942)

Abstract

The wall-building properties of salt-water muds can be maintained at high temperatures by additions of gum karaya, gum ghatti, gelatinized starch, or commercially prepared starch. A germicide should be used to prevent fermentation.

Introduction

The behavior of drilling mud has received special attention from the petroleum industry within the past few years in numerous research projects dealing with such subjects as chemical treatment, gelation, and filtration characteristics.

The importance and control of filtration, or water loss, is readily apparent. It affects the analysis of side-wall cores and interpretation of electric logs; it controls to a large extent the work of primary cementing, reduces the amount of expensive fishing, and permits the running of long strings of casing.

It has been found that among the many factors that have an adverse effect on filtration, the presence of electrolytes, in general, and of salt, in particular, is outstanding. The effect is one of flocculation of the colloids due to neutralization of the negative charges on the clay particles. This reaction is further increased on the Gulf Coast because high temperatures reduce dispersion to a minimum, causing increased flocculation in both fresh-water and salt-water muds. The problem of reducing water loss in salt-water muds by the addition of gums and starch at atmospheric temperature has been investigated,[1] and many successful field tests in West Texas indicate its solution. From the work of Byck[2] it is concluded that no existing method will permit an approximate determination of the filtration rate at high temperatures from data taken at room temperatures. Filtration should be measured at the temperature actually anticipated in the well, or at least at a number of lower temperatures and extrapolated over a small range.

A laboratory study has been made of the chemicals available for the filtration characteristics of salt-water muds at high temperatures, and the use of germicides to prevent fermentation.

Laboratory Investigations

Procedure

Since the purpose of this investigation was to compare several different gums and starches at elevated temperatures, mud from the same source was used for all the tests. Viscosity was measured in a Stormer viscosimeter at 600 r.p.m. and water loss was determined with a Baroid High-pressure and High-temperature Wall-building Tester[3] at temperatures from 80° to 250°F. and at a pressure of 500 lb. per sq. in. for 30 minutes.

The samples tested consisted of 150 grams of commercial Louisiana mud, 50

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[1] References are at the end of the paper.

grams of salt, and 300 grams of tap water. After a short period of mixing, the admixture of starch or gum required to produce a viscosity of about 50 centipoises was added and stirring continued from 30 min. to 2 hr., depending on the difficulty of dispersion. All the admixtures except starch were added to the mud sample in the dry form. Starch was gelatinized by mixing 10 per cent dry starch, 1 per cent caustic soda, and 89 per cent water. Of this sample, 10 per cent, on the basis of total mud weight, was then added to the mud, making a dry starch concentration of 1 per cent. The samples were mixed 10 to 12 hr. before they were tested and at the time of the test were again thoroughly stirred and their density and viscosity determined. All tests were conducted at a constant pressure of 500 lb. per sq. in., a constant salt concentration, a constant weight of 11 lb. per gal., and through a temperature range of 75° to 250°F.

As many of the mixtures fermented in a short time, fermentation tests were made, all samples being in a nonsterile condition and some being treated with germicides such as trichlorophenol and pentachlorophenol.

Results

The results of the tests furnish a comparison of the effectiveness of the different treatments at elevated temperatures and and also the temperature effect on each, through a range of 75° to 250°F.

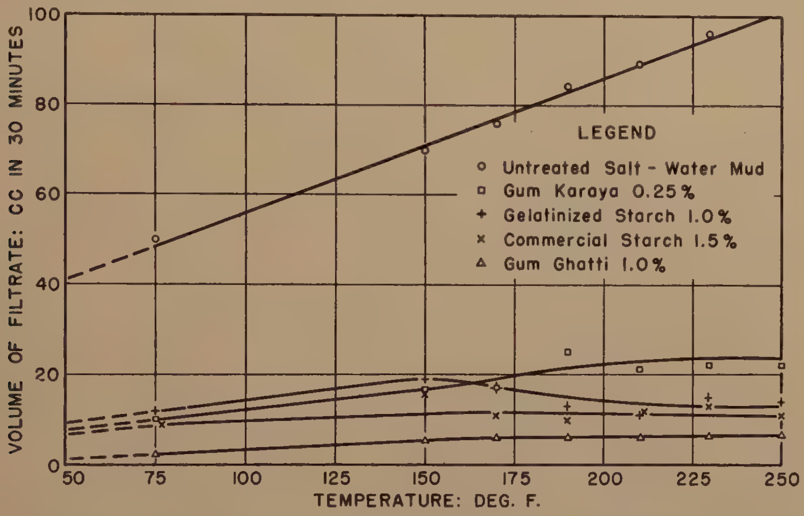

FIG. 1.—COMPARISON OF FILTRATION RATES OF GUMS AND STARCHES ON SALT-WATER MUD AT VARIOUS TEMPERATURES.

Fig. 1 shows the effect of temperature on the total water loss for the four best treatments used. The curve for an untreated salt-water mud shows a filtration loss at 75°F. of 50 c.c. as compared with a loss of 8.7 c.c. when the same mud is mixed with fresh water. The thickness of the filter cake for the salt-water mud was ½ in. While gum ghatti was rather difficult to disperse, it was somewhat more effective and stable than the commercially prepared starch and gelatinized starch, and showed a marked improvement over gum karaya. Treatments with gum karaya in excess of 0.25 per cent by weight resulted in extremely high viscosities. The increasing effectiveness of the two starches above 175°F., based on a greater deviation or lower water loss from the calculated values above this temperature, would suggest that elevated temperatures increase their protective or coating power and consequently decrease the effect of the salt. The gum-treated samples had a better filter-cake texture than those treated with starch. In each case the thickness of the cake was directly proportional to the water loss.

Tests were made on gum arabic, using 2 per cent by weight of mud, up to 150°F., where the water loss was 44 c.c. as compared with an average of 11 c.c. for the other gums and the starches. Because of the high price of gum tragacanth, it did not seem practical for field use.

Fig. 2 shows the effect of various concentrations of commercially prepared starch (water-soluble starch) on viscosity and water loss at two temperatures. It is apparent that concentrations above 1.5 per cent caused a marked increase in viscosity, emphasizing the importance of careful control at the well. The increasing effectiveness of even a small concentration at high temperatures is well illustrated.

Preliminary experiments indicate the possibilities of treating fresh-water muds with these chemicals. Gum karaya and

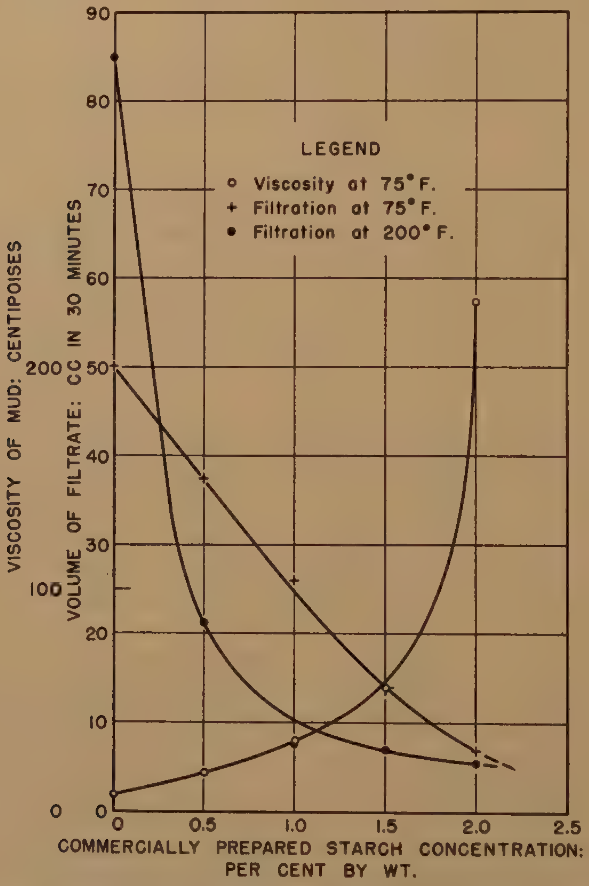

FIG. 2.—EFFECT OF COMMERCIALLY PREPARED STARCH ON VISCOSITY AND FILTRATION OF COMMERCIAL LOUISIANA CLAY IN SALT SOLUTION.

commercially prepared starch reduced the water loss of a fresh-water mud from 7.4 c.c. to 4.5 and 5.1 c.c., respectively; but there was a considerable increase in viscosity.

The gelatinized starch did not ferment in the laboratory or upon the addition of surface soil; however, it is believed that under well conditions bacterial action will take place. Gum karaya and gum ghatti showed slight fermentation upon the addition of surface soil, and the commercially prepared starch showed a marked tendency to ferment under all conditions. Fermentation in each case was readily prevented by the addition of commercial germicides, such as the sodium salt of trichlorophenol and pentachlorophenol at a concentration of 0.5 per cent by weight of the starch or gum used.

Conclusions

Laboratory tests indicate that gelatinized starch, commercially prepared starch, and gum ghatti are very effective reducers of filtration loss at high temperatures. Gum ghatti, while rather difficult to disperse, is the most stable and effective. Commercially prepared starch is recommended for general field use because it is not adversely affected by temperature and is readily available at a reasonable cost, whereas the gums are not available in large quantities in the present world situation. A germicide should be used with all treatments, to prevent fermentation, with the possible exception of the gelatinized starch in highly alkaline muds.

Acknowledgments

The authors are indebted to Baroid Sales Division, National Lead Co., for the commercially prepared starch; to Innis, Speiden and Co. for the samples of gums; to Louisiana Boganite Corporation for the Spud-mud, and to Dowell Chemical Co. for the germicides.

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DISCUSSION

(*H. H. Power presiding*)

G. R. Gray,* Houston, Texas.—I would like to speak of the problem of preventing fermentation of starch in drilling muds.

Drilling mud in the slush pit is exposed constantly to a great variety of air-borne microorganisms. Fresh-water drilling mud containing starch is an excellent culture medium for a number of yeasts and molds, which break down the starch.

Fermentation of starch in mud can be prevented in a number of ways: (1) by adding a germicide; (2) by maintaining a high concentration of dissolved salts; or (3) by keeping the pH of the mud above 13. The use of a germicide is the most difficult of the three methods from the standpoint of field control. The concentration of the agent must be kept above a certain minimum value to prevent fermentation and the analytical determination of such substances is generally troublesome. In contrast, chloride or hydroxyl-ion concentration can be estimated with little difficulty.

Laboratory tests indicated that alcoholic fermentation would not occur in muds containing 5 per cent by weight of sodium chloride. Field experience showed, however, that fermentation continued after the addition of 10 per cent of salt. Thus far no fermentation has occurred in saturated salt-water muds. Within the past three years, Humble Oil and Refining Co. has added starch to salt-water muds used in completing about 150 wells in West Texas without experiencing any trouble from fermentation.

Fermentation of starch in fresh-water muds can be prevented by maintaining a high pH. Since the measurement of the pH of strongly alkaline suspensions with the glass electrode or the Wulff test strips may be subject to large errors, it is considered safer for field control to determine the alkalinity by titration. Sufficient caustic soda is added to the mud to give a concentration of 0.15 to 0.2 per cent as determined by titration with acid. Quebracho extract is added at the same time to prevent a serious increase in viscosity. This treatment generally effects a reduction in water loss from about 20 c.c. to 10 c.c. in 30 min. at 100 lb. per sq. in. test. Starch is then added to bring about a further decrease in filtration. This procedure has been followed in about 30 wells drilled in various locations in Texas and Louisiana, with no evidence of fermentation. In several wells the starch-treated mud was in use for several weeks and in one for three months.

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* Humble Oil and Refining Co.

Chapter III. Geophysical Exploration

The Geophysical History of Darrow Dome, Ascension Parish, Louisiana

By J. Brian Eby,* Member A.I.M.E., and T. I. Harkins†

(New York Meeting, February 1942)

Abstract

This paper outlines the geophysical investigation of the area covering the Darrow salt dome, Louisiana. Surveys with the refraction seismograph and torsion balance failed to disclose the dome, but reflection dip shooting was successful and was confirmed by later drilling.

Introduction

The Darrow salt dome and oil field lies in western Ascension Parish, Louisiana, on the outside of a sharp bend and on the east bank of the Mississippi River. The dome occurs about 30 miles south of Baton Rouge and 80 miles northwest of New Orleans. Its geology, shape and structure have been ably described in detail by Carroll E. Cook[1] and, except for the general features, will not be repeated here. The purpose of this paper is to record some of the interesting and pertinent geophysical data contributing to the discovery of the dome and eventually the oil field.

The salt dome is circular in outline and comes to within about 4625 ft. of the surface. At this depth the diameter of the salt plug is approximately 4800 ft. The dome has only a thin cap rock of less than 75 ft. Some oil has been found and is being produced in Miocene sands above the cap rock, but most of the field's production comes from a narrow ring of wells around the east and south flanks of the dome. Producing horizons on the flank are found at 5670 to 5840 ft. in the Miocene and 6890 to 6985 ft., 7028 to 7060 ft. and 8260 to 8270 ft. in the Oligocene. The deepest well that has been drilled is the Humble Oil and Refining Company's Community B-5, on the south flank of the structure, which reached a depth of 10,013 feet.

The size and shape of the field and the area of production are indicated on Fig. 1. The line showing the area of production encloses all wells now producing and all abandoned producers, both on the top and flank of the dome. This line of production is shown on all subsequent geophysical maps as a direct means of comparing the early geophysics to later drilling development.

Darrow dome occurs on the low, flat flood plain of the Mississippi River; it is protected from flood overflow by high artificial levees. The rich loamy soil supports a high degree of cultivation, principally sugar cane. Drainage is secured by many small canals and the water table of the area is at or near the surface. These particular conditions of topography, drainage and top soil greatly influenced the early geophysical picture, and the influence was always unfavorable.

Surveys with Refraction Seismograph and Torsion Balance

A reported oil show in a water well drew attention to the lands of the Belle Helene

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[1] C. E. Cook: Darrow Salt Dome, Ascension Parish, Louisiana. *Bull.* Amer. Assn. Petr. Geol. (1938) **22**, 1412–1422.

Sugar Co. in 1927, and leases were taken by the Union Sulphur Co. and Gulf Refining Co. The Belle Helene Sugar Co. property is a few miles north of the present known dome. Following this leasing program, the Gulf brought in both refraction seismograph and torsion balance to try to define a dome.

At that time (1927 and 1928) the eastern Louisiana Gulf Coast area was undergoing an intensive competitive geophysical examination. Many major oil companies and operators had refraction seismograph and torsion balance crews in operation. Any evidence of specific block leasing by any one company was a signal for other oil companies to enter into competitive geophysics and leasing. The situation at Darrow, however, was one of such relative inaccessibility for geophysical instruments that the block was acquired practically intact by Union and Gulf before any material geophysical information became available to anyone, the Union and Gulf included.

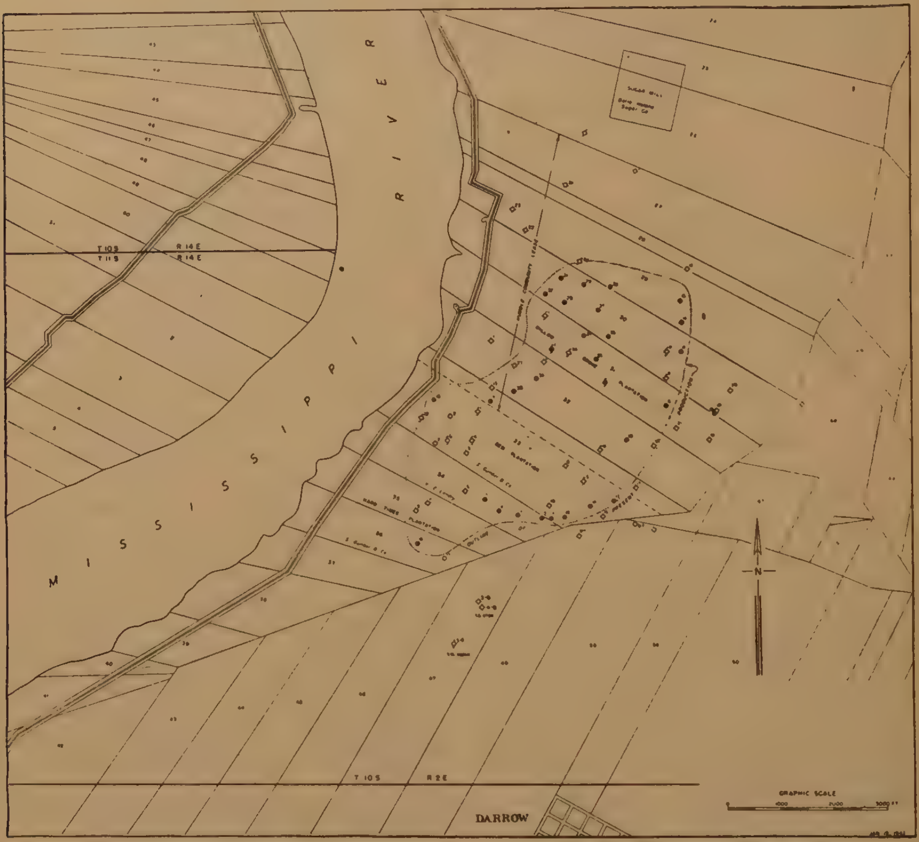

Fig. 1.—Development map of Darrow dome, Ascension Parish, Louisiana.

As a result of repeated refraction shooting and gravity work in 1927 and early 1928, the impression persisted that Darrow was a dome but failed of definition. One of the first refraction seismograph reports of this area, dated early in 1927, made the interesting comment that there seemed to be a domelike uplift of the deeper formations, which appeared to be shaped like a ridge. The ridge was reported to be very small in its east-west extension, but its longer axis ran about parallel to the Mississippi River. This investigation did not warrant the assumption of a deep dome, as the degree of the disturbance was very slight.

By March 1928, out of the many geophysical attempts to outline a salt-dome structure at Darrow, there emerged a so-called torsion balance picture and an area of refraction seismograph interest. These interpretations are combined on Fig. 2, showing several closing gravity isogals and one enclosing refraction line. The authorships of both outlines are unknown and are given here partly as evidence of the activity of scouting departments and partly to attest the general reliability of early geophysical indications, where both methods tended to confirm one another. The gravity map shown in Fig. 2 is believed to be in tenths of milligals and the refraction outline was supposed to be the 5000-ft. contour on salt.

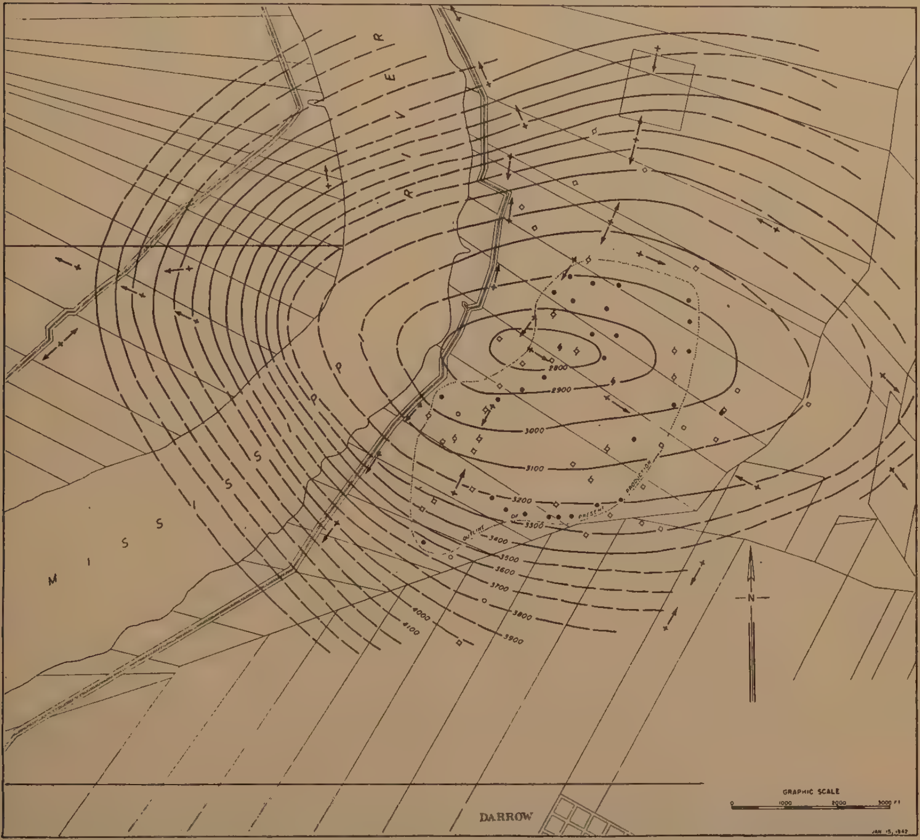

FIG. 2.—REFRACTION SEISMOGRAPH AND EARLY TORSION BALANCE MAP OF DARROW DOME.

A complete torsion balance picture of Darrow dome and vicinity, made before the dome was proved by drilling, is given by Fig. 3, which was compiled from data furnished by Gulf Refining Co. The gravity picture shows all gradients obtained by the survey and isogal lines are indicated, the solid lines representing $\frac{1}{10}$ milligal and the dotted lines $\frac{1}{5}$ milligal. The outline of present production shows the dome to lie almost exactly in the center of the gravity minimum.

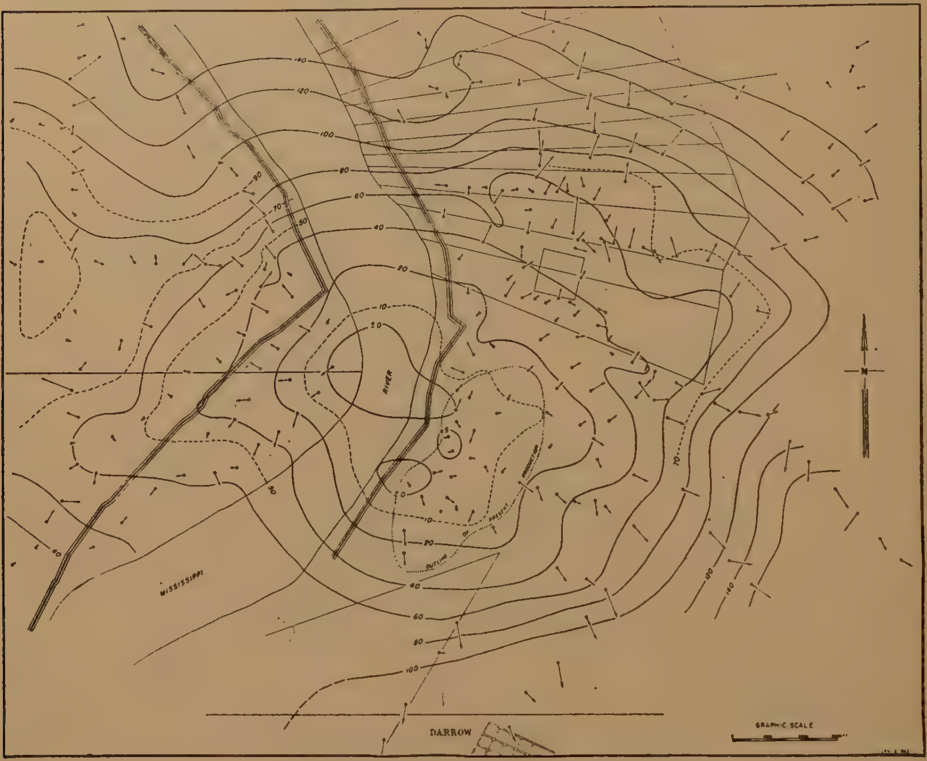

FIG. 3.—TORSION BALANCE MAP OF DARROW DOME.

At the time of the Darrow torsion balance investigation, December 1927 to May 1928, very little was known about the influence of regional gravity. The Sorrento dome near by had already been discovered, and it was recognized that at Sorrento there was a greater gradient flight both north and south than would be expected from the dome picture, so that it could have been guessed that Darrow was in a regional gravity minimum of great width. The construction of the isogals at Darrow was somewhat arbitrary because there could be no stations in the area covered by the river. The closure from the lowest isogal to the west is 7 milligals. The further increases of gravity on the north, east and west were subsequently found to represent regional effects.

Since neither the refraction seismograph nor the torsion balance produced clear-cut positive evidence of the occurrence of a salt dome at Darrow, it was realized that other methods would have to be tried out to determine the true situation. Reflection seismograph work had not yet been attempted in the Gulf Coast, and because of lease considerations the Gulf drilled a well to 5606 ft. in sec. 27, just south of the Belle Helene Sugar Mill (well in sec. 27 marked No. 1 on Fig. 1). This well did not find any dome indications. A well was drilled in the west part of sec. 32 (see well marked No. 1 on Fig. 1) to a depth of 3780 ft., but this also failed to disclose the dome.

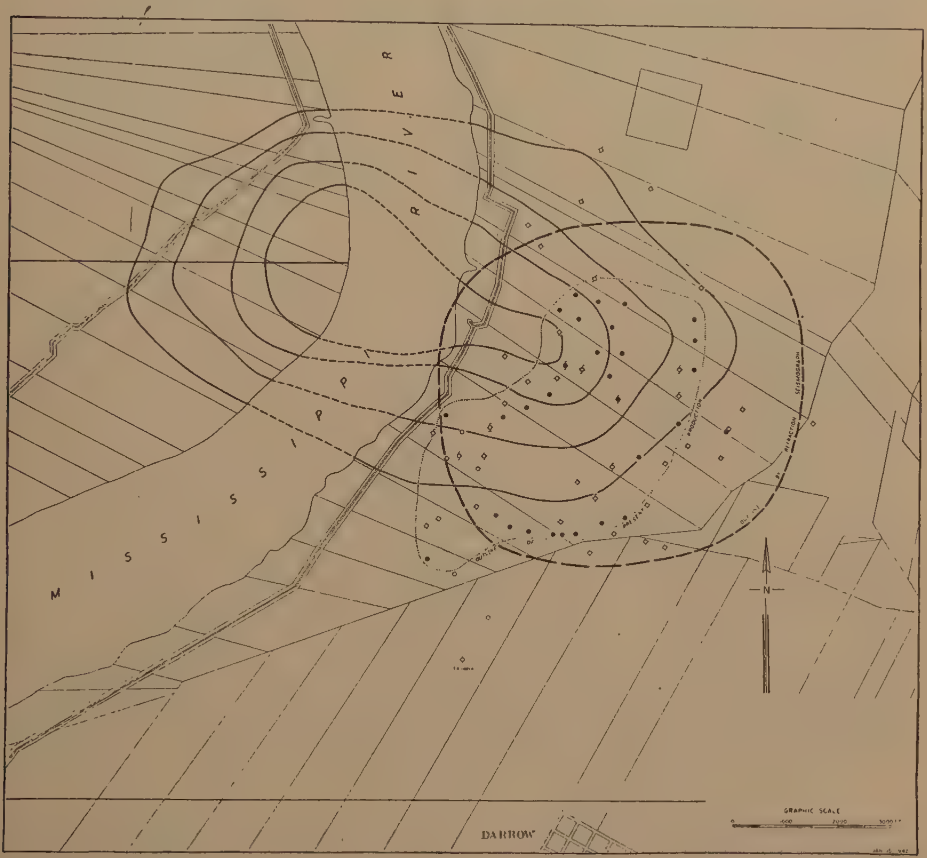

FIG. 4.—REFLECTION SEISMOGRAPH MAP SHOWING DIPS AND CONTOURS OF DARROW DOME.

REFLECTION SURVEYS

In order to try out on the Gulf Coast the reflection technique that had been developed by the Geophysical Research Corporation in Oklahoma, the junior writer's crew, which had been making refraction surveys in New Mexico, was equipped in the summer of 1929 with reflection apparatus, remaining under the supervision of Mr. E. McDermott and in the employ of the Gulf. Some two months were spent on the investigation of other prospects by the reflection method before the work at Darrow was started.

The area represented a difficult problem for reflection shooting, for two principal reasons: (1) the very soft nature of the surface alluvium, which absorbed much energy; (2) the fact that the formations for several thousand feet below the surface were also soft, consisting of sands and clays; the sands varying in thickness rapidly in short distances, and apparently containing none of the hard rock interfaces that had served as reflecting horizons in Oklahoma.

Up to this time it was thought that the only way to make use of reflections was to obtain prominent or persistent reflections that could be correlated. This was found to be almost impossible in most of the Gulf Coast area worked, so it was necessary to obtain some aid for the correlations.

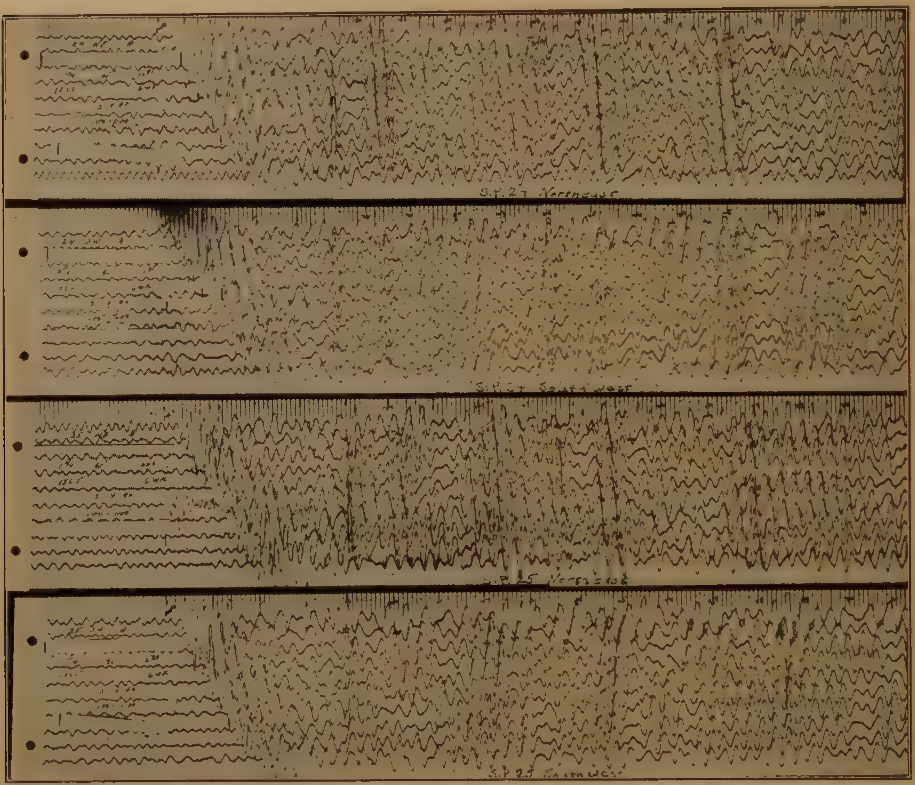

FIG. 5.—REFLECTION RECORDS, SHOOTING FROM TWO DIAMETRICALLY OPPOSITE DIRECTIONS.

At Darrow, for the first time, reflection shooting (Fig. 4) was attempted where, unknown to the geophysical party, there were very steeply dipping beds; that is, the salt flank and the sediments above it. The field method used was to set detectors first in one direction from the shot point and then in the opposite direction. In this area the first setup was along the highway, so that the two opposite directions were nearly north and south, and at a position on the south flank of the dome.

In the method just described, the reflection time of arrival at more distant detectors should be greater than those nearer to the shot point, and if the reflection horizons are horizontal, the times on both lines from the shot point would show similar time differences between the reflection arrivals at near and distant detectors.

On this location at Darrow, however, the reflections on the north line actually showed less time for the far detector than for the near one, and the reflections on the south line showed much greater difference in reflection time between near and far detectors than is normal for the over-all time. This can be due only to a steep south dip on the reflecting horizon.

None of the records obtained in this area was available at the time this paper was written, but Fig. 5 is included to show four reflection records taken in an entirely different area with modern reflection equipment. The two shot points in this figure were shot in diametrically opposite directions, and in each case strong northeast dip was found. There is a negative differential time on the record shot to the southwest, and an excessive differential time on the records shot to the northeast. In other areas investigated, negative differential times had been noted but had been attributed to differential weathering or timing variations, as only two-element oscillographs had been used up to a few months previous to this time. With the use of the multiple-element oscillograph, it was possible to record four or five different geophone (detector) positions on a single record, as in the records of Fig. 5.

An effort was made in this investigation to correlate all reflections obtained with the aid of differential times. That this was successful is shown by the reflection contours shown on Fig. 4 in connection with the outline of present production. No deep reflections were found around what is now known to be the top of the dome.

Chronological List of Wells Drilled on or in Vicinity of Darrow Dome

July–August 1929

Prior to reflection shooting as shown on Fig. 4	
Big Dome Oil Co., Rearwood No. 1	4880 ft. T.D. No dome material
Gulf Refining Co., Belle Helene No. 1	5605 ft. T.D. No dome material
Belle Helene Oil Co., D. Breaux No. 1	3780 ft. T.D. No dome material
Subsequent to reflection shooting as shown on Fig. 4	
Rio Bravo Community No. 1	4035 ft. oil-salt; 4677–4900 ft. T.D.
Rio Bravo Community No. 2 (Humble)	4846 ft. top salt; 4861 ft. T.D.
Rio Bravo Gumbel No. 1	6025 ft. top salt 6052 ft. T.D. salt
Gulf Ref. Co., Community No. 1	4683 ft. top salt 4883 ft. T.D. salt
Humble Oil & Ref. Co Community No. 1	4627 ft. No dome material
Humble Oil & Ref. Co. Gumbel No. 1	5781 ft. No dome material
Humble Oil & Ref. Co. Community No. 5	5674 ft. top salt 5684 ft. T.D. salt
Humble Oil & Ref. Co. Gumbel No. 3	5948 ft. No dome material
Humble Oil & Ref. Co. Community No. 6	5686 ft. No dome material
Humble Oil & Ref. Co. Gumbel No. 4	6033 ft. top of salt 6645 ft. T.D.,salt
Humble Oil & Ref. Co. Community No. 8	5636 ft. No dome material
Humble Oil & Ref. Co. Gumbel No. 5	6841 ft. top salt 6901 ft. T.D. salt
Humble Oil & Ref. Co. Community No. 9	5418 ft. top salt 5715 ft. T.D. salt

The first well drilled after the completion of the reflection picture, the Rio Bravo Oil Company's Community No. 1, found Miocene oil at 4025–4035 ft. and topped the salt at 4627 ft. This well was drilled on reflection information, and not only proved the dome but is the highest salt well drilled in the field to this time. The Rio Bravo well was completed Sept. 26, 1932, nearly three years after the reflection investigation. The accompanying list of wells indicates the chronology of all wells drilled immediately prior and subsequent to the reflection work, and the results of such drilling. This is visible evidence of the successful application of this method of geophysics.

RELATIVE MERITS OF THREE METHODS

The authors believe the Darrow reflection survey to be of real historical interest, because it marked the first step in the development of dip shooting, and because the quality of this type of work was good enough in this early stage to be confirmed so accurately by later drilling. In appraising the relative merits of the three types of geophysics used at Darrow dome, the reader must think back to the period during which the work was done. The fact that refraction shooting showed acceleration in one direction and not in another did not conform to all previous dome structures, which showed acceleration in all directions. It was not until later, for example, that refraction work over Goose Creek oil field, Harris County, Texas, showed as much as a tenth second acceleration in one direction and none at all in other directions. This is not the place to explain such anomalies, but to point out that they do exist over some known structures.

In defense of refraction work and the torsion balance, however, it must be pointed out again that the lack of accessibility of the area as a whole and the poor top and subsoil conditions considerably handicapped these services at Darrow. Nevertheless, both did give some, if not satisfactory, dome indications. The significance of the work on Darrow is that it was there that reflection dip shooting was initiated in the Gulf Coast area and proved successful.

Chapter IV. Petroleum Economics

World Consumption of Petroleum and Its Substitutes during 1942

By V. R. Garfias* and R. V. Whetsel,* Members, and J. W. Ristori,*
Associate Member A.I.M.E.

(New York Meeting, February 1943)

Since the entry of the United States into global war, virtually all data and information necessary for compiling figures on world petroleum consumption have become unavailable. This situation undoubtedly will continue until the world petroleum industry can return to a peacetime basis.

During the past 10 years, the authors, by publishing annual estimates of world consumption, have attempted to emphasize the importance of a yearly world-wide survey of petroleum supply and demand. It is becoming more and more evident that statistics for the United States alone can no longer give a comprehensive idea of the state of the petroleum industry, even within the United States itself. Therefore, when conditions in the industry again become normal, it is the hope of the authors that those bureaus equipped to do so will carry forward the study of petroleum supply and demand on a world-wide basis.

Enough data and information are available, however, to attempt a rough estimate of world output of crude petroleum and petroleum substitutes for 1942, which to some extent may reflect the trend of world consumption. This estimate by countries, as compared with the output in 1941, is shown in Table 1.

The world production of crude petroleum and petroleum substitutes for 1942 is estimated at 2,208,000,000 bbl., or a decrease of 171,000,000 bbl. under 1941. Crude production is believed to have decreased by about 200,000,000 bbl., (about 9 per cent); while petroleum substitutes increased by 28,500,000 bbl., (nearly 20 per cent). The decline of crude output in the United States is estimated at 19,000,000 bbl.—less than 2 per cent; while that in foreign countries is estimated at 180,000,000 bbl., or more than 20 per cent. The marked decline abroad is due largely to losses in Venezuela and Colombia, where the lack of ocean transportation became the controlling factor, and in the East Indies and Burma, where military invasion brought about the destruction of the fields. The production of petroleum substitutes in 1942 apparently reached a new high figure of 7.5 per cent of the total world petroleum output.

The important features of petroleum production outside of the United States are the changes that have taken place during the year in the supply of the Axis countries. In Japan the output for 1941 was estimated at 8,800,000 bbl., 5,500,000 of which were petroleum substitutes. It is believed that the output of synthetic oils during 1942 substantially increased, raising the total interior production of Japan to nearly 10,000,000 bbl. Also, during 1942 Japanese armed forces gained possession of oil fields having a normal peacetime output of about 78,000,000 bbl. per year. The production of these areas for 1942 is estimated at some 23,000,000 bbl., which indicates that Japan is now getting at least 33,000,000 bbl. a year, which exceeds by 8,000,000 bbl. its

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greatest peacetime yearly consumption. As long as Japan can hold the conquered fields of Dutch East Indies and Burma it will encounter no difficulty as to sources of supply. Its greatest problem will be ocean transportation and, to some extent, refining equipment.

The production of petroleum and petroleum substitutes in the European Axis countries appears to present a somewhat different picture, as is shown in Table 2.

The output for 1942 of the European Axis countries and controlled areas is roughly estimated at about 112,000,000 bbl.,

TABLE 1.—*World Production of Crude Petroleum and Its Substitutes*
THOUSANDS OF BARRELS

Countries	1941			1942[a]		
	Crude	Petroleum Substitutes	Total	Crude	Petroleum Substitutes	Total
U. S. A.	1,404,180	67,680	1,471,860	1,385,000	79,000	1,464,000
U. S. S. R.	240,000	1,500	241,500	212,000	2,000	214,000
Venezuela	223,000	1,200	224,200	145,000	1,500	146,500
Iran	78,000	1,000	79,000	76,000	1,000	77,000
Netherlands Indies	62,120	1,000	63,120	9,000	200	9,200
Mexico	41,200	1,000	42,200	35,000	800	35,800
Rumania	40,500	2,000	42,500	41,000	2,000	43,000
Germany	5,240	32,000	37,240	5,400	46,000	51,400
Colombia	24,400	900	25,300	10,600	900	11,500
Argentina	21,800	500	22,300	22,000	600	22,600
Trinidad	21,200	200	21,400	24,500	200	24,700
Peru	12,900	1,000	13,900	13,500	1,000	14,500
Canada	6,300	3,700	10,000	6,400	3,900	10,300
Iraq	12,500		12,500	14,800		14,800
Japan[a]	3,300	5,500	8,800	3,400	6,900	10,300
Egypt	7,700	200	7,900	8,000	300	8,300
Burma	7,800	100	7,900	2,400	100	2,500
Bahrein Island	6,900	200	7,100	7,800	200	8,000
United Kingdom		7,000	7,000		7,500	7,500
Sarawak	1,340		1,340	500		500
Brunei	5,460		5,460	1,000		1,000
Saudi Arabia	5,870		5,870	6,000		6,000
France	500	4,100	4,600	500	4,800	5,300
Poland	3,310	200	3,510	3,400	300	3,700
British India	2,270		2,270	2,500		2,500
Hungary	2,600	100	2,700	3,800	200	4,000
Ecuador	1,500	50	1,550	1,800	100	1,900
Italy Albania	1,200	300	1,500	1,500	400	1,900
Miscellaneous	700	4,200	4,900	800	4,300	5,100
	2,243,790	135,630	2,379,420	2,043,600	164,200	2,207,800

[a] Estimated.

TABLE 2.—*Estimated Production of Crude Petroleum and Its Substitutes by the European Axis Powers*
THOUSANDS OF BARRELS

Country	1941			1942		
	Crude	Petroleum Substitutes	Total	Crude	Petroleum Substitutes	Total
Rumania	40,500	2,000	42,500	41,000	2,000	43,000
Germany	5,240	32,000	37,240	5,400	46,000	51,400
France	500	4,100	4,600	500	4,800	5,300
Poland	3,310	200	3,510	3,400	300	3,700
Hungary	2,600	100	2,700	3,800	200	4,000
Italy Albania	1,200	300	1,500	1,500	400	1,900
Miscellaneous	200	2,000	2,200	200	2,100	2,300
	53,550	40,700	94,250	55,800	55,800	111,600

or 20 per cent greater than in 1941. From many reliable sources, it is reported that Germany is steadily increasing its synthetic oil output. The figure of 46,000,000 bbl. for 1942 is an average of several estimates. If these reports are true almost 50 per cent of the German supply is now petroleum substitutes.

The increase in the production of petroleum substitutes may indicate the ineffectiveness of aerial attacks on German synthetic plants or that the location of all of these widely distributed plants is not known. On the other hand, Rumanian crude production, which constitutes over 35 per cent of the whole European Axis output, is confined to a small area, definitely known, where continuous bombing could within a short time make effective inroads upon the German oil supply.

Petroleum consumption figures of the European Axis powers are even more conjectural than those of production. An average of several estimates is about 13,000,000 bbl. per month during active military operations and 9,000,000 bbl. per month between campaigns. This would indicate that when military operations are passive small accumulations are possible, but when they are active shrinkage of reserve oil stocks could be considerable.

All of these guesses notwithstanding, it seems reasonably certain that the difference between the petroleum supply and demand of the European Axis powers cannot be great. Therefore it is logical to assume that extensive efforts are justified toward the destruction of Axis sources of petroleum supply, wherever they can be found.

Chapter V. Production

Introduction

By Basil B. Zavoico,* Member A.I.M.E.

The symposium on production for the year 1942 contains no papers on the foreign situation except those on Argentina and Mexico. It has always been the policy of officers in charge of the symposium to refrain from publishing information that might possibly injure national or private interests. At the close of the war we hope again to publish full and accurate records of production abroad.

Excerpts from Circular to Authors

In order to facilitate interpretation of the data in this chapter, we print the following excerpts from the Circular to Authors.

The field is the unit in this tabulation. In cases of fields extending across State boundaries, such as Rodessa, it is suggested that each State author treat the section of the field in his State as a unit, and by a footnote indicate that the field extends into an adjacent State.

Each space in Table 1 may represent one of four possibilities; either it is not applicable to the particular field, or the proper entry is not determinable, or the proper entry may be determinable but is not determinable from data available to the author, or the proper entry is determinable. When spaces are not applicable, leave blank; in spaces where the proper entries are determinable but not determinable from data available to the author, please insert *y*; in spaces where the proper entries are determinable by the author, make such entries. *y* implies a hope that in some future year a definite figure will be available.

The entry of a zero is a positive declaration, and it is an important declaration where it is in order.

Inability to determine precisely the correct entry for a particular space should not lead the author to insert merely *y*. Contributions of great value may be made by the author in many cases where entries are not subject to precise determination. In such cases the author should use his good judgment and make the best entry possible under the circumstances. For many spaces the correct entries represent the opinion of the author (for example, "Area Proved") and in such cases the entry need not be hedged to such extent as when the quantities are definite yet can be ascertained only approximately by the author.

In cases under definite headings but where figures are only approximate, the author may use *x*.

It is thought that the nearest whole numbers are sufficiently accurate for our purposes except as to percentage of sulphur in oil. If an author desires to report any other figures to tenths, he may do so.

The quantity of gas produced should include, where possible, gas sold or otherwise marketed, and gas blown into the air, burned as flares or otherwise wasted. Segregation of these figures would be interesting if the authors can make such segregation. In any event, the figures should represent as nearly as possible the total quantity of gas removed from the reservoir.

Under the columns on "Depth," the average depth to the top of the productive zones and to the bottom of the productive wells, when subtracted, should give the approximate thickness of the productive zone. For fields where this is not true because of unusually high dip or for some other reasons, it is suggested that the authors indicate in their text the approximate average thickness of the productive zone.

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* Assistant Director, Division of Reserves, Petroleum Administration for War, Washington, D.C.; Chairman for Production, A.I.M.E. Petroleum Division, 1942–1943.

The net thickness of the producing formation should be the thickness of the producing zone, less the estimated amount to cover the portions of the zone that do not yield oil, such as dense shales, etc. It is recognized that for some fields the authors can only make rough guesses; in such cases, they should enter either *x* or *y*, whichever is appropriate, and production per acre-foot will have to be treated in a similar manner. Average production per acre-foot can be calculated by those interested from the figures given.

In classifying wells as to producing methods, enter all wells that are not "flowing" in the column headed "Artificial Lift." If desirable, add footnotes to indicate whether the lift is "pumping," "gas lift" or "air lift."

It is recognized that for many fields it would be very difficult to determine accurately the quantity of each gravity of oil produced. However, the approximate weighted average gravity, which will be representative of the total production can be determined sufficiently accurately to constitute significant information.

FOOTNOTES TO COLUMN HEADINGS—TABLE I

[a] All fields to be listed alphabetically for the district; or alphabetically by counties in alphabetical order.

[b] Areas where both oil and gas are produced, unless gas is marketed outside the field, are included in column headed "Oil." Manufacture of casinghead gasoline and carbon black is interpreted as outside marketing of gas.

[c] Wells producing both oil and gas are classified as "Producing Oil." Gas wells are those producing gas, but include those producing wet gas, from which casinghead gasoline may be produced.

[d] State by letters, as indicated, type of operation: PM, pressure maintenance from early life of field; RP, field repressuring in its later life; SR, repressuring operations of secondary recovery type.

[e] Cam, Cambrian; Ord, Ordovician; Sil, Silurian; Dev, Devonian; Mis, Mississippian; MisL, Lower Mississippian; MisU, Upper Mississippian; Pen, Pennsylvanian; Per, Permian; Tri, Triassic; Jur, Jurassic; CreL, Lower Cretaceous; CreU, Upper Cretaceous; Eoc, Eocene; Olig, Oligocene; Mio, Miocene; Pli, Pliocene.

[f] S, sandstone; H, shale; L, limestone; OL, oölitic limestone; LS, limestone, sandy; C, chalk; A, anhydrite; D, dolomite; Da, arkosic dolomite; Gw, granite wash; P, serpentine; Cgl, conglomerate.

[g] Figures are entered only for fields where the reservoir rock is of pore type. Figures represent ratio of pore space to total volume of net reservoir rock expressed in per cent. "Por" indicates that the reservoir rock is of pore type but said ratio is not known by the author. "Cav" indicates that the reservoir rock is of cavernous type; "Fis," fissure type.

[h] A, anticline; AF, anticline with faulting as important feature; Af, anticline with faulting as minor feature; AM, accumulation due to both anticlinal and monoclinal structure; H, strata are horizontal or near horizontal; MF, monocline-fault; MU, monocline-unconformity; ML, monocline-lens; MC, monocline with accumulation due to change in character of stratum; MI, monocline with accumulation against igneous barrier; MUP, monocline with accumulation due to sealing at outcrop by asphalt; D, dome; Ds, salt dome; T, terrace; TF, terrace with faulting as important feature; N, nose; S, syncline.

Oil and Gas Development in South Arkansas in 1942

By Alec M. Crowell,[*] Member A.I.M.E., and C. H. Thigpen[†]

Continuing the increase in production of crude oil and condensate started in 1937, the oil fields of South Arkansas reached a 13-year peak with 26,570,704 bbl. for the year 1942. The stability of the production branch of the industry in the area is demonstrated by Fig. 1, which reflects the fact that although the number of producing wells in the state has declined from 3280 in 1931 to 2957 at the end of 1942, total production has continuously increased since the beginning of 1937. This is because all fields discovered since Jan. 1, 1937, have observed spacing patterns up to one well to each 160 surface acres, the dual completion of wells where there is more than one producing horizon and close adherence to advanced operating practices.

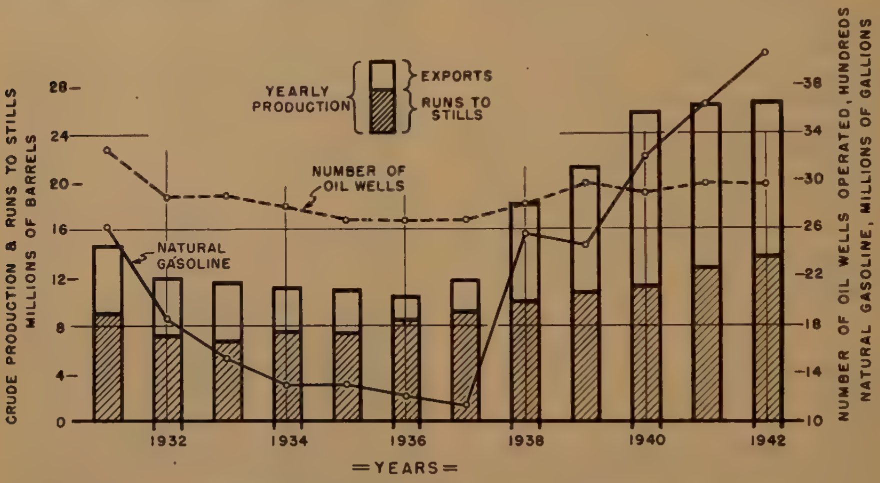

Fig. 1.—Petroleum production graph for Arkansas, 1932–1942.

Eight new pools were brought into production in South Arkansas during 1942 (Fig. 2). They increased the state's crude oil and condensate reserve by 121,000,000 bbl., bringing the total recoverable reserve figure to 450,000,000 bbl. (Table 3) as of Jan. 1, 1943.

Abandonment of wells in the stripper areas of the state increased by 32 per cent over the preceding year, there having been 142 wells permanently abandoned in 1942. For economic reasons 279 wells were temporarily shut down as of Dec. 31, 1942. A price increase may start these wells to pumping again and also be the incentive toward the commencing of several secondary recovery projects in the fields discovered between 1922 and 1937.

There were 149 wells brought into production in 1942 as against 119 for the

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previous year, the production of oil-well gas increased over 8 billion cubic feet for the year and natural gasoline was recovered from this gas in the amount of 40 million gallons, an increase of 6 million gallons over the previous year. Proven fields were further defined by 35 dry holes and 45 of the wildcats drilled during the year were dry. As the year ended there were 12 wells drilling in proven fields and 13 wildcats in operation.

Purification of sour gas produced in the area continued to expand during 1942, resulting in the location of additional war industries. Two fields were well on the way to complete dual completion of wells, while field casing corrosion due to action of hydrogen sulphide in the annular space of producing wells was discovered and rectified and preparations were made for the broadening of a secondary recovery program in the state.

SUCCESSFUL REPRESSURING PROJECT

The Schuler field, Jones sand, repressuring project, which was started in 1941, continued to operate successfully throughout 1942. There were 8.5 billion cubic feet of gas produced and 7.7 billion cubic feet returned to the reservoir. The weighted volumetric reservoir pressure drop for 1942 was only 28 lb. per sq. in., while the oil production amounted to 4,495,622 barrels.

The Schuler Jones sand pool has a total of 146 wells, of which 140 are in the unit operation. Production is taken from approximately 35 wells which have low gas-oil ratios. The high gas-oil ratio wells are closed in except six which are used to return gas to the reservoir. There is no active water drive present in the pool, purely a volumetric reservoir of proven depletion type.

A high-pressure absorption gasoline plant is also operated by the Schuler Jones sand unit. Approximately 25 million cubic feet of gas is processed daily, resulting in the daily production of approximately 18,000 gal. of 22-lb. gasoline and about 10,000 gal. of butane-propane mixture.

CASING CORROSION

Oil-string casing corrosion which resulted in casing leaks was detected in several wells in the Magnolia pool. After each well in the pool had been tested, it was found that the casing leaks occurred in the static gas column. The two theories offered as to the source of the trouble were electrolysis, or chemical reaction in the static gas column. (The hydrogen sulphide content of the gas is 1200 grains per 100 cu. ft.) After two consulting engineers, experienced in corrosion problems, had made a survey of conditions, it was their recommendation that packers be set in each well just above the producing horizon with a heavy sweet fuel oil or mud left above the packer. These recommendations were carried out by all operators in the Magnolia pool and operators in other sour gas pools are reworking their wells in the same manner on the very good assumption that if it will cure, it will prevent.

DUAL COMPLETION WORK

Dual completions in the Dorcheat and Macedonia fields became common practice during the year, with nine dual completions in each field in operation as the year closed. The two producing horizons, the Smackover lime and the Cotton Valley series, were produced simultaneously by setting packers between the two productive zones and producing the Cotton Valley (upper zone) through the casing and the Smackover lime (lower zone) through the tubing.

Dual completion of wells as a means of permitting the concurrent production from the Cotton Valley formation through a well and also bringing production to the surface from the Smackover limestone formation without the commingling of fluids or gas from the two formations is highly desirable from an economic standpoint.

TABLE 1.—*Oil and Gas Production in South Arkansas*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
										During 1942		End of 1942			Number of Wells	
			Oil	Gas[b][3]	To End of 1942[6]	During 1942[6]	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
1	Atlanta, *Columbia*..	1938	880	0	2,861,120	1,034,327	3,910	1,397	22	3	0	0	22	0	20	2
2	Big Creek, *Columbia*	1939	0	160[2]	116,236	47,336	2,800	1,228	2	1	1	0	0	1	1	0
3	Bradley, *Lafayette*..	1925	80	0	186,705	0	*x*	0	6	0	0	0	0	0	0	0
4	Buckner, *Columbia, Lafayette*........	1937	1,130	0	3,393,757	762,643	880	200	28	2	1	0	28	0	11	17
5	Camden, *Ouachita*..	1934	10	0	37,848	(Abd. 1940)	*x*	0	1	0	0	0	0	0	0	0
6	Champagnolle, *Union*..........	1927	2,030	*x*	15,180,512	269,551	*x*	*x*	243	3	1	6	75	1	1	75
7	Columbia, *Columbia*	1942	40[2]	0	0	0	0	0	1	1	0	0	1	0	1	0
8	Dorcheat, *Columbia*		1,240[2]	0	1,750,767	627,393	17,030	5,661	37	19	1	10	27	0	37	0
9	Cotton Valley[4]	1942	640[2]	0	52,336	52,336	135	135	11	11	0	10	1	0	11	0
10	Reynolds.....	1939	1,240[2]	0	1,698,431	575,057	16,895	5,526	26	8	1	0	26	0	26	0
11	El Dorado East, *Union*[1]..........	1922	1,400	*x*	9,610,639	126,307	*x*	*x*	203	8	3	8	55	3	0	58
12	El Dorado South, *Union*..........	1920	7,980	*x*	48,729,607	371,133	*x*	*x*	1,116	0	3	6	187	0	0	187
13	Fouke, *Miller*......	1940	260[2]	0	526,958	324,987	24*x*	22*x*	13	7	2	0	13	0	0	13
14	Garland City, *Miller*..........	1932	290	0	2,072,307	87,585	*x*	*x*	28	0	1	2	9	0	0	9
15	Haynesville, *Columbia*[5]......	1942	80[2]	0	1,060	1,060	0.5	0.5	1	1	0	0	1	0	1	0
16	Irma, *Nevada*......	1921	900	0	7,228,300	191,416	*x*	*x*	150	0	0	5	73	0	0	73
17	Lewisville (Stamps), *Lafayette*........	1939	400	0	538,824	64,452	334*x*	50*x*	19	0	0	1	18	0	0	18
18	Lisbon, *Union*.....	1925	2,700	*x*	6,822,506	59,760	*x*	*x*	356	0	0	5	143	0	0	143
19	Macedonia, *Columbia*........		1,520[2]	0	526,333	396,771	6,316	4,567	28	22	0	8	20	0	28	0
20	Cotton Valley[4]	1942	720[2]	0	17,608	17,608	70	70	9	9	0	8	1	0	9	0
21	Reynolds.....	1941	1,520[2]	0	508,725	379,163	6,246	4,497	19	13	0	0	19	0	19	0
22	Magnolia, *Columbia*	1938	4,494	1,200	24,714,702	6,366,089	21,870	5,920	116	0	0	0	115	0	107	8
23	McKamie, *Lafayette*		2,880	0	1,694,056	722,367	12,138	5,412	19	5	2	0	19	0	18	1
24	Cotton Valley.	1942	40[2]	0	15,635	15,635	3	3	1	1	0	0	1	0	0	1
25	Reynolds.....	1940	2,880	0	1,678,421	706,732	12,135	5,409	18	4	2	0	18	0	18	0
26	Midway, *Lafayette*..	1942	1,252[2]	0	1,222,247	1,222,247	338	338	31	31	11	0	31	0	30	1
27	Mt. Holly (McDonald), *Ouachita*........	1929	60	0	117,085	(Abd. 1931)	*x*	0	6	0	0	0	0	0	0	0
28	Mt. Holly, *Union*..	1941	200[2]	0	139,739	129,316	955	913	5	4	1	0	5	0	5	0
29	NewLondon, *Union*	1942	360[2]	0	67,965	67,965	13	13	9	9	2	0	9	0	7	2
30	Nick Springs, *Union*	1940	130	0	615,526	127,732	250	39	14	0	0	0	13	0	0	13
31	Patton, *Lafayette*...	1941	80[2]	0	25,519	12,727	124	22	2	1	1	0	1	0	1	0
32	Rodessa, *Miller*....	1937	1,950	200	6,607,521	367,567	40,125	5,941	123	0	10	10	50	10	0	60

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Including several small producing areas.

[2] Areas of Big Creek, Columbia, Dorcheat, Fouke, Haynesville, Macedonia, McKamie-Cotton Valley, Midway, Mt. Holly, New London, Patton, Schuler-Cotton Valley, Stephens-Smart, and Texarkana are not yet fully defined.

[3] Big Creek, Dorcheat, Macedonia, McKamie-Reynolds, and Texarkana are classiffied as gas-condensate pools. Although Dorcheat has a 15-ft. oil column with a maximum 75-ft. gas cap, experience has proved that in attempting to produce only the oil column water coning will result. Thus it is necessary to perforate higher and the resultant production is a straw-colored to water-white condensate. Atlanta, Magnolia, Mt. Holly-Reynolds, Patton, Schuler-Jones, Schuler-Reynolds, and Village have gas caps which are not being produced with the exception of a few relatively high gas-oil ratio wells in Village and Mt. Holly-Reynolds. Buckner and Midway are undersaturated pools.

[4] Dorcheat and Macedonia Cotton Valley wells are dual completions. The Smackover lime is produced through the tubing while the Cotton Valley is produced through the casing.

[5] Haynesville is an extension into Arkansas from Louisiana.

[6] Production figures not final; subject to minor changes.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
										Depth, Avg. Ft.					
	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	3,821	3,450		45	0.47	Reynolds	Jur	OL	15	8,202	8,227	5	A	Smackover	8,332
2	3,723	3,723		69	0.05	Reynolds	Jur	OL	13	7,959	7,995	36	A	Smackover	7,999
3	*x*	*x*		26	0.43	Buckrange	CreU	S	Por	2,785	2,790	5	A	Paluxy	3,555
4	3,195	2,526		31	2.0	Reynolds	Jur	OL	20	7,200	7,260	30	A	Smackover	7,444
5	*x*	*x*		16	2.56	Nacatoch	CreU	S	Por	1,356	1,369	13	ML	Travis Peak	2,500
6	*x*	*y*		22 34	1.42 2.00	Tokio Travis Peak	CreU CreL	S	Por	2,780 3,340	2,800 3,350	15	NL	Eagle Mills	6,911
7	3,750	3,750		65	*y*	Reynolds	Jur	OL	15	8,030	8,070	25	A	Smackover	8,150
8															
9	3,400	3,400		43 62	0.28	Cotton Valley	Jur	S	20	7,850	7,900	25	A	Smackover	9,028
10	4,243	3,300		48 62	0.55	Reynolds	Jur	OL	15	8,815	8,900	60	A	Smackover	9,028
11	*x*	*y*		21 33	1.49	Nacatoch	CreU	S	Por	2,170	2,180	10	TL	Cotton Valley	6,003
12	*x*	*y*		33	1.15	Nacatoch	CreU	S	Por	2,100	2,175	20	ANL	Smackover	7,820
13	1,485	*y*		30	1.30	Paluxy	CreL	S	20	3,583	3,660	25	F	Smackover	9,550
14	*x*	*y*		32 47	1.26 0.44	Paluxy Rodessa	CreL	S	Por	2,925 4,200	2,935 4,215	10	ML	Rodessa	4,432
15	2,500	2,500		38	0.60	Pettit	CreL	OL	17	5,462	5,480	13	Af	Pettit	5,540
16	*x*	*y*		14	2.70	Nacatoch	CreU	S	Por	1,150	1,179	27	AF	Travis Peak	3,735
17	1,450*x*	*y*		43	0.66	Blossom Rodessa	CreU CreL	S OL	17	3,400	3,500	20	TF	Smackover	7,420
18	*y*	*y*		34	1.08	Nacatoch	CreU	S	Por	2,100	2,120	20	ML	Smackover	6,861
19															
20	3,400	3,400		45 68	0.02	Cotton Valley	Jur	S	20	7,900	8,100	12	AL	Smackover	9,020
21	4,130	3,735		62	0.13	Reynolds	Jur	OL	14	8,870	8,955	75	A	Smackover	9,020
22	3,465	3,048		39	0.90	Reynolds	Jur	OL	17	7,350	7,600	100	A	Smackover	7,824
23															
24	2,831	*y*		42	0.04	Cotton Valley	Jur	S	Por	7,255	7,265	10	AL	Eagle Mills	9,980
25	4,365	4,152		59	0.19	Reynolds	Jur	OL	17	9,125	9,300	106	A	Eagle Mills	9,980
26	2,920	2,724		35	1.38	Reynolds	Jur	OL	25	6,340	6,550	75	Af	Smackover	6,750
27	*x*	*x*		30	*y*	Travis Peak	CreL	S	Por	2,800	2,813	7	ML	Travis Peak	3,378
28	3,180	3,153		44	0.77	Reynolds	Jur	OL	20	7,146	7,175	26	A	Smackover	7,373
29	2,650	*y*		31	1.88	Cotton Valley	Jur	S	18	5,700	5,850	25	AL	Smackover	6,100
30	1,600	*y*		39	0.80	Travis Peak	CreL	S	Por	3,153	3,762	15	AF	Smackover	6,819
31	4,380	*y*		47	0.60	Reynolds	Jur	OL	16	9,312	9,503	30	A	Smackover	9,503
32	2,800	*y*		43	0.38	Rodessa	CreL	S-LS	25	6,050	6,100	25	AF	Rodessa	6,514

The Smackover formation is blanket in type, served by an active water drive but productive of extremely sour gas. The Cotton Valley formation is highly lenticular (as many as 27 lenses indicated productive in a single well). These lenses are small, often missing in 40-acre offset wells, and productive of oil as often as gas condensate. The gas is sweet.

Positive shutoffs to prevent commingling of sweet and sour gas have proved difficult. While there is a market for both gas and oil from both formations, it is felt that much closer spacing than the present one well to 80 surface acres will be necessary to properly deplete the indicated oil reserve of the Cotton Valley formation. Separate wells will be necessary to produce the sweet gas from the Cotton Valley reservoirs if it is to be kept free of hydrogen sulphide contamination.

A Dually Completed Well

Interesting is a résumé of operations in a dually completed well, The Carter Oil Co., J. H. Kirkpatrick No. 1 well in the N.½ of sec. 13, T. 18 S., R. 22 W., Dorcheat field, Columbia County, Ark. The 6-in. o.d. oil string was set at 8997 ft. and the cement plug drilled out to 8957 ft. The casing was perforated opposite the Cotton Valley with a combination McCullough gun and testing tool run on 2½-in. tubing. A total of 36 one-half inch shots was used in opening the Cotton Valley at 7856 to 7865 feet.

The drill stem test, made with a testing tool, gave a rate of 78 bbl. of condensate per day, with a gas-condensate ratio of 22,756 cu. ft. per bbl. The Cotton Valley perforations were then reamed and the Smackover perforated at 8936 to 8945 ft. with 36 one-half inch shots.

The McCullough tester failed to seal, so a Halliburton tester was set at approximately 8900 ft., following which the well was swabbed for a recovery of mud and salt water with a small show of oil. These perforations were then squeezed, the cement plug drilled out to 8942 ft. and the casing perforated at 8928 to 8941 ft. with 52 one-half inch shots.

The well came in through the tester and produced 12 bbl. brownish 53° A.P.I. condensate and 96 bbl. salt water in 15 hr. through a ⅜-in. bottom and ¼-in. top hole choke with 650 lb. flowing pressure. A Baker bridge plug was then set at 8920 ft.

TABLE 1.—(*Continued*)

Line Number	Field, County	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
										During 1942		End of 1942			Number of Wells	
			Oil	Gas[b,d]	To End of 1942[a]	During 1942[a]	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
33	Schuler, *Union*....		2,944	200	32,272,031	5,720,572	41,202	9,757	183	5	3	102	80	0	61	19
34	Cotton Valley.	1942	140[2]	0	201,649	201,649	469	469	7	5	0	0	7	0	7	0
35	Jones Sand....	1937	2,944	200	25,552,670	4,495,622	34,996	8,474	146	0	0	102	44	0	40	4
36	Morgan Sand..	1937	300	0	2,507,984	236,602	2,018	174	14	0	3	0	14	0	0	14
37	Reynolds.....	1937	606	200	4,009,728	786,699	3,719	640	16	0	0	0	15	0	14	1
38	Schuler East, *Union*	1941	240	100	231,093	194,771	655	409	6	3	0	0	6	0	5	1
39	Smackover, *Ouachita, Union*..		25,760	*x*	393,915,129	4,892,789	*x*	*x*	3,760	1	67	66	1,603	0	0	1,603
40	Heavy........	1922	16,000	*x*	338,170,457	4,207,390	*x*	*x*	*y*	0	*y*	36	1,140	0	0	1,140
41	Light.........	1922	9,600	*x*	55,495,498	651,028	*x*	*x*	*y*	1	*y*	29	460	0	0	460
42	Snow Hill.....	1936	160	*x*	249,174	34,371	*x*	*x*	6	0	0	1	3	0	0	3
43	Stephens, *Columbia, Nevada, Ouachita*	1922	3,000	*x*	6,903,910	179,663	*x*	*x*	312	2	2	40	194	0	0	194
44	Stephens, *Columbia*	1941	800[2]	0	512,295	444,388	101	87	22	15	3	0	22	0	0	22
45	Texarkana, *Miller*..	1942	160[2]	0	11,690	11,690	348	348	1	1	0	0	1	0	1	0
46	Troy, *Nevada*......	1936	500	0	2,367,418	406,534	*x*	*x*	51	3	0	6	43	0	0	43
47	Urbana, *Union*...	1930	500	0	7,130,457	915,661	*x*	*x*	85	1	2	4	66	0	0	66
48	Village, *Columbia*..	1938	480	250	1,569,455	423,905	7,067	1,373	13	1	0	0	12	0	12	0
49	Total...........		69,026	2,310+	579,701,317	26,570,704	10,156,480+	43,697+	7,012	149	117	279	2,942	15	347	2,628

and the Smackover again perforated at 8880 to 8912 ft. with 129 one-half inch shots.

On a drill-stem test, with a ¼-in. top and bottom choke, the well made 30 bbl. water white 65.7° condensate in 4 hr. with a tubing head pressure of 1550 to 1650 lb. On the state test, through a 9/64-in. choke, the well produced at the rate of 72 bbl. condensate per day with a gas-condensate ratio of 19,100 and with a flowing tubing pressure of 2550 pounds.

In making the dual completion, a Baker-type 415-C retainer production packer was set at 8858 ft. The cone-type positive seal ordinarily used in this installation was replaced by a polished joint with four synthetic rubber pack-off rings. This joint is designed to run on the bottom of the tubing string and to hand with the seals in the packer. Use of a number of seals allows free vertical movement of the tubing string due to expansion or contractions as the result of slight temperature changes without leakage occurring through the packer. A metal ring was welded above the top seal to prevent unseating of the packing rings by excessive expansion.

The danger of tubing leaks in the string was eliminated in so far as possible by the treating of all tubing joints with Rectorseal. In the completion, the production tubing was run in and spaced to seat the seals in the packer and the installation tested with pump pressure to 1500 lb. The polished joint was then lifted out of the packer and the mud in the casing above the packer displaced with water. The tubing string was swabbed until the Cotton Valley commenced flowing, the Smackover being sealed off by the flapper valve in the packer. The polished joint was then set back into the packer and the Christmas tree connections bolted down. A ram-type Cameron

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
33															
34	3,090	2,635		42	0.34	Cotton Valley	Jur	S	16	6,900	6,925	10	AL	Smackover	8,328
35	3,520	1,460	RP	34	1.46	Cotton Valley	Jur	S	17	7,530	7,610	42	A	Smackover	8,328
36	2,000x	y		42	0.56	Cotton Valley	Jur	S	16	5,500	5,750	15	AL	Smackover	8,328
37	3,550	3,355		37	0.91	Reynolds	Jur	OL	15	7,600	7,635	26	A	Smackover	8,328
38	2,509	1,747		44	0.36	Cotton Valley	Jur	S	25	5,580	5,810	14	AL	Smackover	7,702
39															
40	x	y		19 23	2.02 2.36	Nacatoch Graves Tokio	CreU	S	Por	2,000 2,450 2,600	2,025 2,475 2,610	40	Af	Eagle Mills	7,255
41	x	y	SR	21 27	1.77 2.24	Nacatoch Meekin	CreU	S	Por	2,000 2,275	2,025 2,300	30	ALf	Igneous	7,973
42	x	y		36	1.08	Reynolds	Jur	OL	25	4,800	4,960	30	AF	Eagle Mills	5,708
43	x	y		13 31	2.87 1.60	Nacatoch Buckrange	CreU	S	Por	1,500 2,100	1,510 2,110	15	NLF	Smackover	6,053
44	1,625x	y		32	0.75	Travis Peak	CreL	S	Por	3,390	3,450	10	A	Smackover	5,965
45	3,418	3,358		71	0.3	Reynolds	Jur	OL	14	7,350	7,420	50	A	Smackover	7,700
46	x	y		14 22	2.24 2.51	Nacatoch Tokio	CreU	S	Por	1,243 2,160	1,250 2,167	10	F	Eagle Mills	6,143
47	x	y		19 33	2.03 1.14	Nacatoch Travis Peak	CreU CreL	S	Por	2,270 3,560	2,280 3,570	10	A	Cotton Valley	4,501
48	3,350	3,180		44	0.77	Reynolds	Jur	OL	20	7,390	7,350	25	A	Smackover	7,603
49															

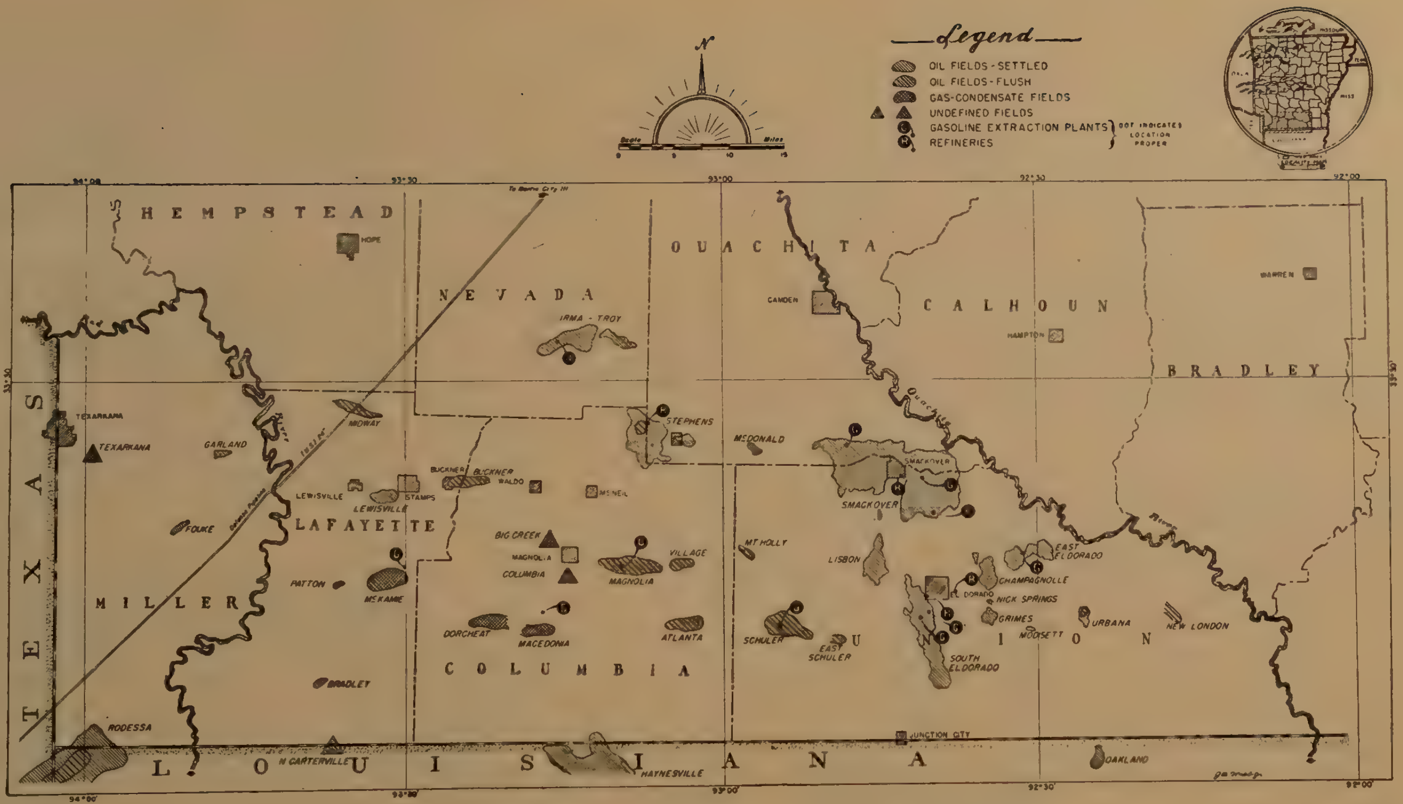

FIG. 2.—OIL AND GAS-CONDENSATE FIELDS OF SOUTHERN ARKANSAS.

The significance of the flush oil fields and flush gas-condensate fields of Arkansas can be readily observed by referring to Table 1 and Table 3. These flush fields, while smaller in area than the settled fields, contain much greater and more easily managed reserves, owing to the higher reservoir pressures encountered at increased depths. These pressures are being maintained through optimum production practice.

TABLE 2.—*Summary of Drilling Operations in Southern Arkansas*

Important Wildcats Drilled in 1942

	County	Location			Total Depth, Ft.	Surface Formation
		Sec.	Tp.	Rge.		
1	Bradley	3	16 S	10 W	5,673	Terrace deposits
2	Bradley	28	15 S	10 W	6,301	Terrace deposits
3	Bradley	16	17 S	10 W	5,609	Alluvium
4	Bradley	11	16 S	12 W	5,050	Terrace deposits
5	Calhoun	24	15 S	13 W	5,206	Terrace deposits
6	Calhoun	28	14 S	14 W	4,992	Terrace deposits
7	Calhoun	27	15 S	14 W	4,980	Alluvium
8	Clark	2	11 S	20 W	2,085	Alluvium
9	Clark	4	11 S	19 W	817	Terrace deposits
10	Columbia[1]	15	18 S	21 W	8,898	Claiborne
11	Columbia[1]	16	18 S	22 W	7,888	Claiborne
12	Columbia	21	15 S	21 W	6,717	Claiborne
13	Columbia	23	17 S	21 W	8,125	Claiborne
14	Columbia	10	20 S	20 W	5,540	Claiborne
15	Columbia	15	17 S	22 W	8,590	Claiborne
16	Columbia	12	16 S	19 W	6,666	Claiborne
17	Hempstead	2	14 S	25 W	6,101	Wilcox
18	Hempstead	32	14 S	23 W	6,403	Wilcox
19	Howard	7	8 S	28 W	1,410	Trinity
20	Jefferson	35	3 S	11 W	2,775	Jackson
21	Jefferson	36	6 S	9 W	705	Alluvium
22	Lafayette	11	15 S	24 W	6,536	Terrace deposits
23	Lafayette	5	15 S	24 W	6,561	Terrace deposits
24	Lafayette	30	17 S	23 W	9,429	Claiborne
25	Lafayette	17	15 S	23 W	6,598	Wilcox
26	Lafayette	14	15 S	24 W	6,529	Wilcox
27	Lafayette	4	19 S	23 W	10,477	Terrace deposits
28	Lafayette	15	15 S	25 W	7,276	Alluvium
29	Lafayette	3	15 S	24 W	6,579	Terrace deposits
30	Lafayette	1	15 S	24 W	625	Terrace deposits
31	Little River	18	12 S	29 W	3,726	Terrace deposits
32	Little River	8	13 S	31 W	1,990	Alluvium
33	Little River	36	11 S	31 W	1,301	Terrace deposits
34	Lonoke	17	5 N	10 W	3,224	Atoka
35	Miller	3	16 S	28 W	7,700	Terrace deposits
36	Miller	4	15 S	28 W	6,510	Midway
37	Miller	2	15 S	26 W	6,685	Alluvium
38	Nevada	33	12 S	20 W	4,037	Wilcox
39	Nevada	4	13 S	22 W	4,050	Wilcox
40	Ouachita	30	13 S	17 W	2,510	Alluvium
41	Ouachita	16	15 S	19 W	3,753	Claiborne
42	Ouachita	17	13 S	16 W	3,602	Alluvium
43	Ouachita	6	15 S	18 W	2,507	Claiborne
44	Ouachita	15	12 S	17 W	3,505	Alluvium
45	Saline	18	3 S	15 W	370	Alluvium
46	Union	4	18 S	12 W	6,290	Claiborne
47	Union	26	16 S	14 W	5,735	Claiborne
48	Union	18	19 S	15 W	2,910	Claiborne
49	Union	36	16 S	17 W	6,500	Claiborne
50	Union	13	18 S	12 W	5,870	Claiborne
51	Union	1	19 S	13 W	4,004	Claiborne
52	Union	25	18 S	15 W	7,465	Claiborne
53	Union	1	18 S	12 W	6,282	Claiborne
	Total				271,667	

[1] Cotton Valley discovered by dual completion methods. Smackover Lime produces through tubing and Cotton Valley zones produce through casing.

tubing head was used in this installation, which permits control of the casing at all times and allows the tubing string to be raised and lowered under pressure as was necessary for swabbing in of the upper pay. The regular Christmas tree master valve afforded control of the tubing string. From all tests to date, this dual completion has been successful.

In so far as the cost of drilling this well is concerned, the information is incomplete, but, as nearly as can be determined, cost of the well, including casing, tubing, Christmas tree, etc., was approxi-

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1942

	Deepest Horizon Tested	Drilled by	Initial Production per Day		Choke or Bean, Inch	Pressure, Lb. Per Sq. In.		Remarks
			Oil, U. S. Bbl.	Gas, Million Cu. Ft.		Casing	Tubing	
1	Eagle Mills	Placid Oil Co.						Dry and abandoned
2	Eagle Mills	Placid Oil Co.						Dry and abandoned
3	Smackover lime	Placid Oil Co.						Dry and abandoned
4	Smackover lime	Placid Oil Co.						Dry and abandoned
5	Smackover lime	Placid Oil Co.						Dry and abandoned
6	Smackover lime	Placid Oil Co.						Dry and abandoned
7	Smackover lime	Skelly Oil Co.						Dry and abandoned
8	Eagle Mills	Coker & Greives						Dry and abandoned
9	Nacatoch	Coker & Greives						Dry and abandoned
10	Cotton Valley	Atlantic Ref. Co.	115	2.40	19/64	2,200		66° A.P.I.
11	Cotton Valley	Atlantic Ref. Co.	170	2.50	19/64	2,300	2,100	65.5° A.P.I.
12	Smackover lime	M. S. Lake						Dry and abandoned
13	Smackover lime	Roy Lee, Trustee	150	1.8	19/64	1,800	1,900	51° A.P.I.
14	Lower Pettis lime	Navarro Oil Co.	1,106	0.20	3/8	1,000	250	38.4° A.P.I.
15	Smackover lime	Sinclair-Prairie Oil Co.						Dry and abandoned
16	Smackover lime	Southwood Oil Co.						Dry and abandoned
17	Smackover lime	Barnsdall Oil Co.						Dry and abandoned
18	Smackover lime	Hygrade Producing Co.						Dry and abandoned
19	Paleozoic	T. DeGrazier, et al.						Dry and abandoned
20	Paleozoic	Curtis-Low Oils, Inc.						Dry and abandoned
21	Sparta	Frank Stratton, et al.						Dry and abandoned
22	Smackover lime	Barnsdall Oil Co.	638	0.04	15/64	750	830	36.5° A.P.I.
23	Smackover lime	Barnsdall Oil Co.						Dry and abandoned
24	Smackover lime	Carter Oil Co.	288	0.007	1/4	525	300	46.2° A.P.I.
25	Smackover lime	Frankel & Riddel Petr. Co.						Dry and abandoned
26	Buckner	Gene Goff						Dry and abandoned
27	Smackover lime	McAlester Fuel Co.						Dry and abandoned
28	Smackover lime	Mid-Continent Petr. Corp.						Dry and abandoned
29	Smackover lime	P. R. Ruthford						Dry and abandoned
30	Midway	E. P. Wingfield						Dry and abandoned
31	Paleozoic	A. Gutowsky et al.						Dry and abandoned
32	Paluxy	W. S. King						Dry and abandoned
33	Paluxy	J. G. Strahan						Dry and abandoned
34	Paleozoic	J. F. Russel						Dry and abandoned
35	Smackover lime	The Carter Oil Co.	96	2.6	7/32	0 (Packer)	2,600	70.6° A.P.I.
36	Smackover lime	Sylvester-Wadley, et al.						Dry and abandoned
37	Smackover lime	Tidewater Asso. Oil Co.						Dry and abandoned
38	Smackover lime	H. L. Hunt						Dry and abandoned
39	Smackover lime	M. E. Wakefield						Dry and abandoned
40	Travis Peak.	Joe Bander						Dry and abandoned
41	Travis Peak.	The Hunter Co.						Dry and abandoned
42	Eagle Mills	J. F. Magale						Dry and abandoned
43	Tokio	Milam & Bond						Dry and abandoned
44	Eagle Mills	North Central Texas Oil Co.						Dry and abandoned
45	Wilcox	A. W. Givens						Dry and abandoned
46	Smackover lime	Amerada Petr. Corp.						Dry and abandoned
47	Smackover lime	Bruce Anthony						Dry and abandoned
48	Blossom	Sam Kinard						Dry and abandoned
49	Smackover lime	Lion Oil Refining Co.						Dry and abandoned
50	Cotton Valley	Marine Oil Co.	100	0.04	1/4	0	100	31° A.P.I.
51	Travis Peak	Stanley Mitchell						Dry and abandoned
52	Smackover lime	Crescent Drilling Co.						Dry and abandoned
53	Smackover lime	N. H. Wheless Drilling Co.						Dry and abandoned

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	11	7
Number of oil wells completed during 1942	141	8
Number of gas wells completed during 1942	0	0
Number of dry holes completed during 1942	35	45

mately $78,100. It is estimated that a single zone completion to 8000 ft. would cost $65,600 and one to 9000 ft. would cost $76,700. Thus, by dual completion, a saving of $64,200, or 45 per cent of the cost of the two wells, was realized.

DEVELOPMENT AND EXPLORATION

At the end of 1942 there were 64 known undrilled subsurface structures in South Arkansas. Approximately 90 per cent of these were located by seismograph.

Of the 229 wells drilled during the year, 35 were dry holes in proven fields, 45 were wildcat dry holes, 104 were completed as oil wells, and 45 were completed as gas-condensate wells. Eight new pools were discovered, three of which were Smackover lime pools, four were Cotton Valley pools, and one Pettit lime pool. The Smackover lime pools were: Columbia (condensate), Midway (oil), and Texarkana (condensate). The Cotton Valley discoveries were: New London (oil), Dorcheat (oil and condensate), Macedonia (oil and condensate), and McKamie (oil).

Dorcheat and Macedonia Cotton Valley pools were brought into production by dual completion methods. The McKamie Cotton Valley discovery well was a plugback on a Smackover lime well which had produced some lime condensate prior to going to water. The Pettit lime discovery resulted from the Haynesville, Louisiana, Pettit Lime pool, extending into Arkansas.

Columbia Pool.—The Roy Lee, Trustee, Lizzie Pickler No. 1, sec. 23, T. 17 S., R. 21 W., Columbia County, encountered saturation in the Reynolds oölite of the Smackover lime at a depth of 8030 ft. Completion date was Dec. 26, 1942, and initial test was 50 bbl. 65° A.P.I. gravity condensate per day with a gas-condensate ratio of 12,000 cu. ft. per bbl. of condensate. Initial bottom-hole pressure was 3750 lb. per sq. in. The discovery resulted from seismic exploration.

Midway Pool.—Arkansas' outstanding discovery for the year is the Midway pool. Discovered by Barnsdall Oil Company's Edgar Bond No. 1, sec. 11, T. 15 S., R. 24 W. Lafayette County, on Jan. 1, 1942, this Smackover lime pool has added over 50 million barrels to the state's oil reserves. Oil saturation was encountered in the top of the Reynolds oölite at a depth of 6314 ft. and the water level was established at approximately 6500 ft. Initial test was at the rate of 638 bbl. 35° A.P.I. gravity oil per day on $^{15}\!/_{64}$-in. choke. Gas-oil ratio was 257 cu. ft. per bbl. of oil, and initial bottom-hole pressure was 2920 lb. per sq. in. Formation samples revealed the pool to be undersaturated with the saturation pressure being 2525 lb. per sq. in. The discovery resulted from seismic exploration.

Texarkana Pool.—On Sept. 7, 1942, Carter Oil Company's Orr No. 1 well was completed from the Smackover lime as a condensate well. Its location in sec. 3, T. 16 S., R. 28 W., gave Miller County its first production from the Smackover lime. Top of the saturated porosity was encountered at 7348 ft. and the water level was established at 7420 ft. Initial production on a $^{14}\!/_{64}$-in. choke was 68 bbl. of condensate per day and a gas-condensate ratio of 27,286 cu. ft. per bbl. The discovery resulted from seismic exploration.

Dorcheat-Cotton Valley.—The Atlantic Refining Company's Pine Woods B-1 well in sec. 16, T. 18 S., R. 22 W., Columbia County, was plugged back from the Smackover lime and tested the 7850-ft. Cotton Valley zone on Feb. 6, 1942. Initial test showed water-white 71° A.P.I. gravity condensate, and the well was closed to production pending a gas market. Later in the year an offset abandoned Smackover lime well was re-entered and the same zone was tested. The well tested 43° A.P.I. gravity oil with a gas-oil ratio of 6000 cu. ft. per bbl. Nine Smackover lime wells tested the Cotton Valley zone by dual completion methods. Initial tests indicated gas condensate of sufficient volume to warrant commercial production. However, these zones were closed to production because of lack of a market for the gas.

Initial bottom-hole pressure of these zones was 3400 lb. per sq. in. Gas-condensate ratios average approximately 20,000 cu. ft. per bbl. These zones were detected by coring the breaks and electrical logging after seismic exploration had indicated sufficient structure to drill Smackover lime wells.

Macedonia-Cotton Valley.—Similar to Dorcheat, the discovery of Cotton Valley production in this field resulted from dual completion tests from the 8000-ft. Cotton Valley zone and the Smackover lime. As of Jan. 1, 1943, nine Smackover lime wells tested the 8000-ft. Cotton Valley zone by dual completion methods. These initial tests also indicated gas condensate of sufficient volume to produce commercially. This Cotton Valley zone was also closed to production owing to lack of a gas market. However, a market for the gas is anticipated for the Cotton Valley zones in Macedonia and Dorcheat in early 1943.

Initial reservoir pressure was approximately 3400 lb. per sq. in., while gas-condensate ratios are very similar to those in Dorcheat, averaging 20,000 cu. ft. per bbl. This pool was also discovered as a result of seismic exploration.

Although the discovery wells in the Dorcheat and Macedonia fields are six miles apart, the two have progressively developed toward each other until at the present time the east edge of Dorcheat is only 1½ miles from the west edge of Macedonia. There is evidence of a saddle between the two pools. As to whether the saddle will dip below the water table or the two pools connect directly into one pool remains to be proved.

McKamie-Cotton Valley.—The one Cotton Valley well in this pool was discovered as a result of a plug-back job on the Carter

TABLE 3.—*Reserves of Oil and Condensate Pools in Arkansas as of Jan. 1, 1943*

FLOWING OIL POOLS

Field	Reserves	
	Oil, Million Bbl.	Gas, Billion Cu. Ft.
Atlanta	5	9
Buckner	8	1
Dorcheat-Macedonia C.V.	57	112
Magnolia	157	197
Midway	50	34
Mt. Holly	5	9
New London	2	1
Schuler-Jones	32	45
Schuler-Reynolds	3	5
Schuler-Cotton Valley	4	4
Schuler-East	2	2
Village	3	9
Total	328	428

GAS-CONDENSATE POOLS

Field	Reserves	
	Condensate, Million Bbl.	Gas, Billion Cu. Ft.
Big Creek	3	66
Dorcheat-Lime[a]	9	98
Dorcheat-Cotton Valley[b]	3	40
Macedonia-Lime	10	128
Macedonia-Cotton Valley[b]	4	50
McKamie	36	423
Texarkana	5	100
Total	70	905

STRIPPER OIL FIELDS

Field	Reserves
	Oil, Million Bbl.
Champagnolle	0.7
El Dorado	3.6
Fouke	1.2
Garland City	0.2
Irma-Troy	1.5
Lewisville	0.4
Lisbon	0.2
Nick Springs	0.8
Rodessa	3.3
Schuler-Morgan	2.0
Smackover	35.0
Stephens	1.2
Urbana	2.2
Total	52.3

State total oil	380.3	million barrels
State total distillate	70	million barrels
State total oil and distillate	450.3	million barrels
State total wet gas	1333	billion cubic feet

[a] An oil field under Arkansas law but classed as gas field by P.A.W. for spacing reasons.

[b] Multiple-lens production in which oil reserves may exceed by far gas-condensate reserves if development proceeds.

Oil Company's Cornelius Unit No. 1, Smackover lime well, sec. 30, T. 17 S., R. 23 W., Lafayette County. This was an edge lime well which had gone to salt water. Perforations in the Cotton Valley zone were from 7255 to 7265 ft., and on Feb. 11, 1942, initial test was 288 bbl. of 46° A.P.I. gravity oil with a gas-oil ratio of 265 cu. ft. per bbl. Initial bottom-hole pressure was 2831 and the well is now pumping. Seismic exploration resulted in the discovery.

New London.—Producing from saturated Cotton Valley zones varying in depth from 5700 to 5850 ft., the New London pool was discovered on April 12, 1942, by the Marine Oil Company's Frost No. 1 well, sec. 13, T. 18 S., R. 12 W., Union County. Initial production test was good for over 100 bbl. 31° A.P.I. gravity oil per day on ¼-in. choke, while gas-oil ratio was approximately 400 cu. ft. per bbl. Initial reservoir pressure was 2850 lb. per sq. in. Nine wells were completed by the end of the year, and total oil production was 67,965 bbl. The discovery resulted from seismic exploration.

Haynesville Extension.—Although this Pettit lime pool was extended into Arkansas on Dec. 15, 1942, by the completion of Navarro Oil Company's S. J. Beene No. 1 well, sec. 10, T. 20 S., R. 20 W., Columbia County, it was originally discovered in Louisiana on Nov. 20, 1941, by the T. L. James, Callie Aiken No. 1 well, sec. 27, T. 23 N., R. 8 W., Claiborne Parish. The discovery well in Louisiana had a depth from surface to the producing horizon of 5420 ft. Initial production test was 228 bbl. of 39° A.P.I. gravity oil per day on ¼-in. choke. Initial bottom-hole pressure was 2270 lb. per sq. in., while the gas-oil ratio was 400 cu. ft. per bbl. The discovery extension well in Arkansas had an initial production test of 240 bbl. of 38° A.P.I. gravity oil per day on a ¼-in. choke. Initial bottom-hole pressure was 2344 lb. per sq. in. and gas-oil ratio was 400 cu. ft. per bbl. Reservoir sample data indicate that the formation oil is fully saturated. The discovery resulted from seismograph.

REGULATION OF PRODUCTION

The Arkansas Oil and Gas Commission continued to control production on an optimum rate basis. Reservoir-pressure drops were held to a minimum, while individual well gas-oil ratios were controlled with a maximum gas-oil ratio limit.

ACKNOWLEDGMENTS

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Natural Gas in Northwest Arkansas

By Alec M. Crowell,* Member A.I.M.E., and Thomas D. Bailey†

Although natural gas was first discovered in Northwest Arkansas in 1887, near Fort Smith, Sebastian County, the literature contains very little information on the region, which is separated distinctly from the oil area of Southern Arkansas. For that reason this brief and concise report is a summary of developments from discovery to the present time.

Northwest Arkansas produced 5,736,000,000 cu. ft. of natural gas during 1942, the trend of production having been generally upward over the past five years, as is shown in Fig. 1.

Since 1904 a reserve of 237 billion cubic feet of natural gas has been discovered in Northwest Arkansas, of which approximately 162 billion cubic feet have been expended, leaving a reserve of approximately 75 billion cubic feet available as of Jan. 1, 1943. A prolific new field discovered in Pope County Oct. 23, 1942, will add to the reserve of the region materially. Per well reserves, over-all, are unusually high because of the practice of multiple completion.

As yet no commercial deposits of oil have been discovered in Northwest Arkansas, but the gas deposits have proved of immense value industrially, principally in the processing of zinc ore mined in the local area as well as that imported from distant states. With the war, new interest in the exploitation of the metallic ores of the region lends new significance to the gas reserves tabulated herein.

Geological Discussion

The region covered in this report comprises the Arkansas Valley from Pope County westward to the Arkansas-Oklahoma state line as shown in Fig. 2. This valley is a westward trending structural trough with sharp-topped ridges and mesa-like mountains rising above the valley's undulating surface. It is bounded on the north by the Ozark Highlands and on the south by the Ouachita Mountains.

The sedimentary beds of the Arkansas Valley are composed mainly of nonfossiliferous shales and sandstones. The rocks contain a high content of carbonaceous material and many coal beds are found in the region. The fixed carbon ratios (ratio of fixed carbon to volatile combustible matter of surface coals) are very high and average about 80 per cent over the region covered in this report. Little or no calcareous material is present. Rocks of the Arkansas Valley are sharply folded, and igneous intrusive rocks cut the sedimentary beds at a few places.

The Arkansas Geological Survey[1] made a detailed reconnaissance survey of the Arkansas Valley province in 1927, the purpose being to delineate the major structural features (Fig. 3) and to point out the possibilities of discovering additional gas deposits. More than fifty anticlines were mapped as a result of this survey. The information gained by this

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[1] Geology of the Paleozoic Area, by Carey Croneis.

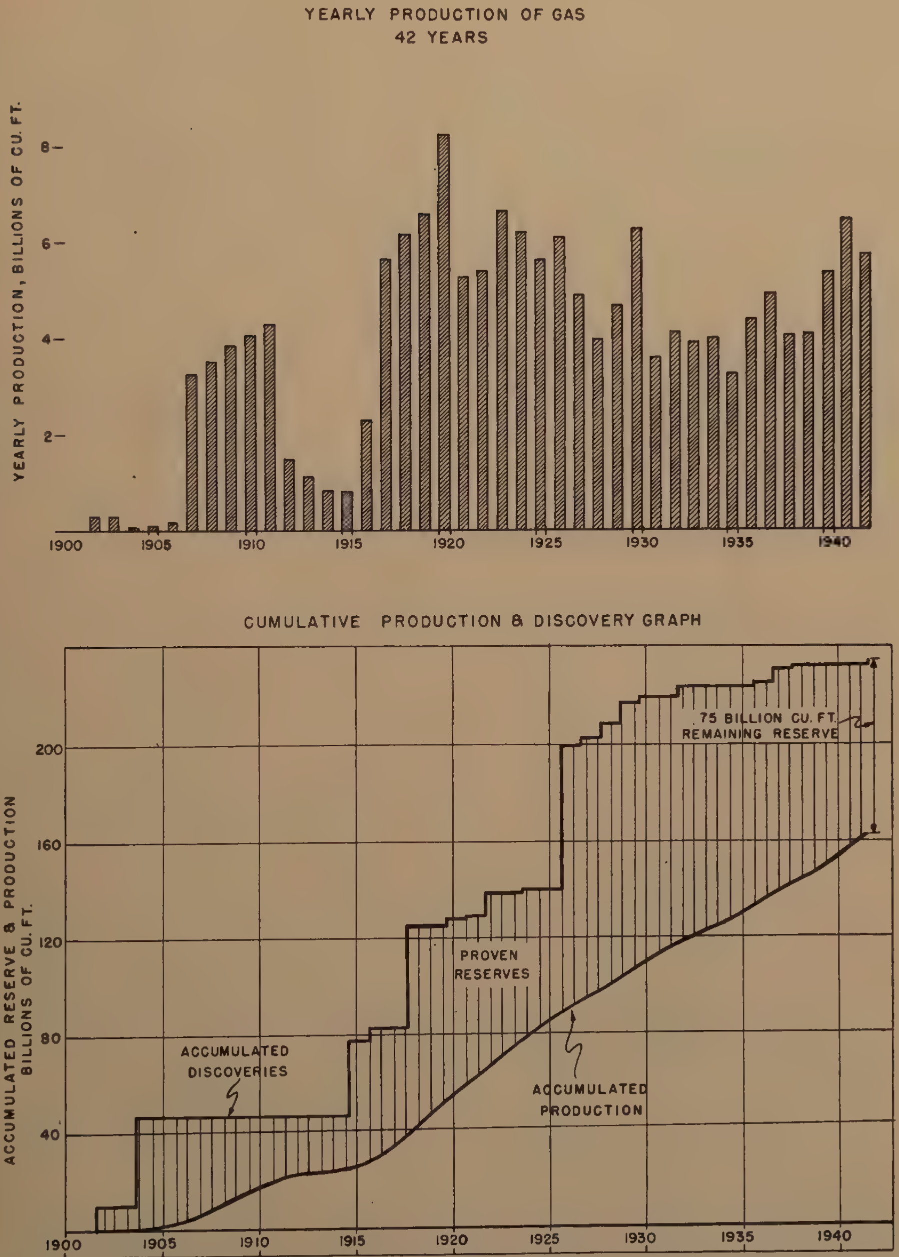

FIG. 1.—TRACING PRODUCTION OF NATURAL GAS IN NORTHWEST ARKANSAS FOR PAST 42 YEARS AND VISUALIZING STATUS OF RESERVES OF NATURAL GAS OVER SAME PERIOD.

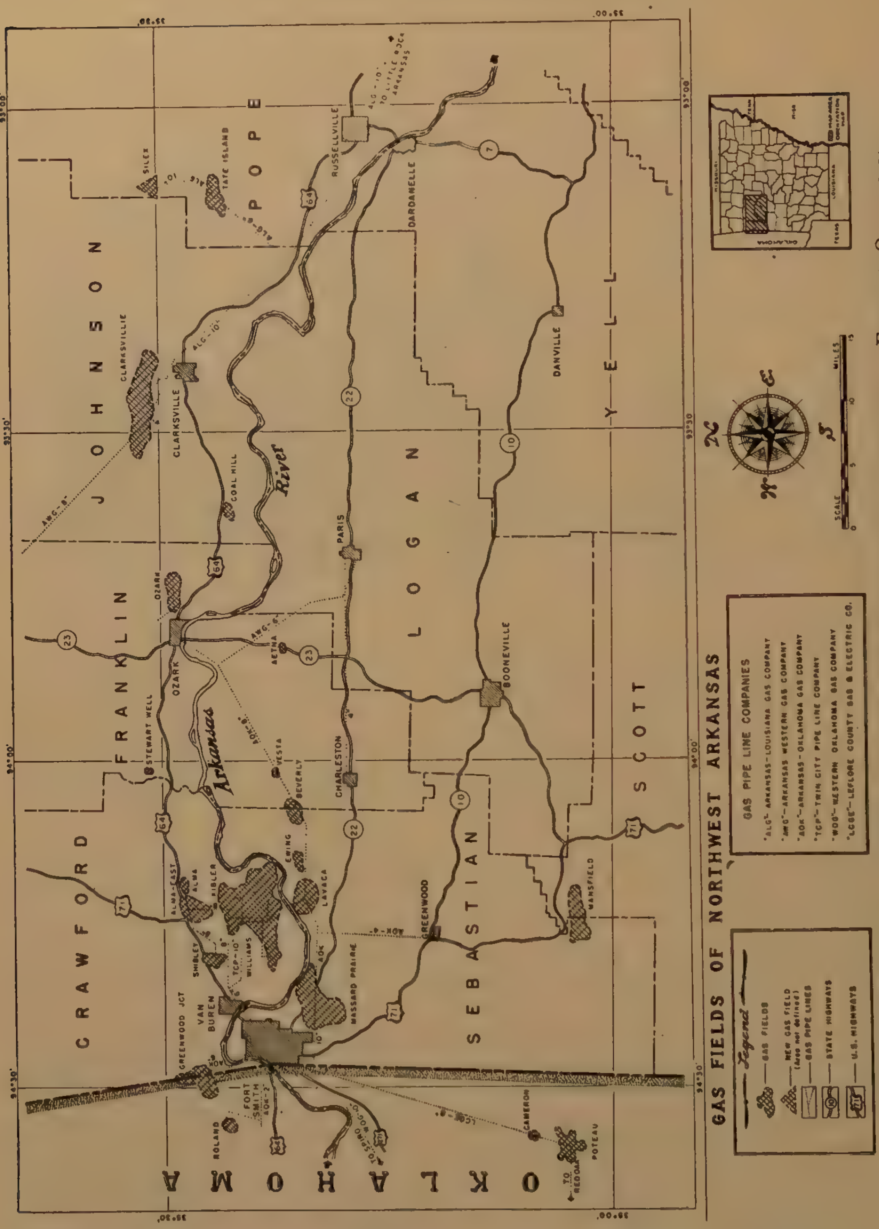

FIG. 2.—NATURAL GAS FIELDS OF NORTHWEST ARKANSAS AND A PORTION OF EASTERN OKLAHOMA.
Showing ownership and size of natural-gas pipe lines, principal state and federal highways, the course of the Arkansas River, with the area oriented by an index map in the lower right-hand corner of the figure.

survey has helped considerably in subsequent discoveries.

Most of the wells drilled in this region penetrate only a part of the Atoka formation. This formation is composed mainly of shale with a few sand lenses of varying thickness distributed throughout the shale. These lenses constitute the possible reservoirs for natural gas. The sand lenses generally do not contain water when penetrated either on or off structure. The porosity and permeability seem to increase as one moves up along the flanks of the structure. On some anticlines no permeability is found on the top of the structure, yet fair permeability is found a few hundred feet downdip on the flanks of the anticline. In most cases the lateral extent of a sand lens is small and offset wells may strike entirely different sections. The gas has supposedly been formed during periods of mountain making from heating and distillation of the carbonaceous material contained in the shale. The gas so formed has accumulated in the void space of the interbedded sand lenses. Permeabilities are low in most of the producing zones but a few wells penetrate sand zones having high enough permeabilities to produce at high initial rates.

All fields discovered to date have been due to surface mapping. The anticlines generally trend in an east-west direction with dips of from 3° to 10° on their flanks. Numerous faults are found in the area.

Cable Tools

Cable tools have been used to drill practically all of the wells drilled to date in northwestern Arkansas and operators will perhaps continue to use them in the future in this region. The hard sand lenses encountered make it impractical to use rotary equipment because of the large number of rotary bits required. Special care must also be used in dressing cable tools so as not to have them become stuck in the hole. In dressing the cable tool bits, the bits are flanged out at the bottom in order to cut a hole larger than the diameter of the main body of the bit.

Completion Practice

Wells drilled during the first 20 years after the commercial discovery of gas in northwest Arkansas were completed in a simple manner. Two or three hundred feet of surface casing was cemented and open hole carried from the bottom of the surface casing down to the bottom of the hole. A tubing string with a packer placed on the lower end was set just above the pay zone. The packer was expanded against the hard cap-rock formation. These packers held fairly well but after a few years service the wells began making small amounts of water. The operators thought that the water was coming from a higher horizon and getting down into the bottom of the wells through leaky packers. To remedy the water problem, cement was poured into the annular space between the tubing and open hole. The cement plug so formed stopped the water production and seemed to offer the best logical solution. However, the wells with tubing cemented in them are in no condition to be reworked or deepened. New wells must be drilled if lower producing zones are discovered in the older fields.

The completion program on wells that have been drilled more recently has been much changed from the original practice. A description of the completion program on Arkansas Louisiana Gas Company's J. R. Hudson No. 1 in SW. SE. NE., sec. 14, T. 10 N., R. 24 W., Clarksville field, Johnson County, is a good example of the completion practice followed today. Drilling commenced Sept. 28, 1930, and the well was completed Jan. 22, 1931.

The following casing strings were set in the hole: (1) 20 ft. of 20-in.; (2) 234 ft. 16-in.; (3) 1592 ft. 13⅜-in.; (4) 2622 ft. 10¾-in.; (5) 2890 ft. 8⅝-in.; (6) 3030 ft. 6⅝-in.; and (7) 3165 ft. of 2-inch.

The well is producing from three zones; namely, the Russell sand from 2848 to 2875 ft., the Patterson sand from 2995 to 3025 ft., and the Kelly sand from 3155 to 3165 ft. Initial rock pressures on these three zones were 770, 810, and 1125 lb. per sq. in., respectively. The Russell sand is produced from the annulus between the 10¾-in. and the 8⅝-in. casing strings; the Patterson sand produced from the annulus between the 8⅝-in. and the 6⅝-in. strings; and the Kelly sand is produced

TABLE I.—*Oil and Gas Production in Northwest Arkansas*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production,[2] Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1941	During 1942	To End of 1942	During 1942	[a]Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
1	Aetna, *Franklin*	1928	0	200	0	0	665	50	2	0	0	0	0	2
2	Alma, *Crawford*	1916	0		0	0	13,163	70	26	0	0	0	0	8
3		1916	0	300	0	0	4,521	10	9	0	0	0	0	3
4		1922	0	y	0	0	8,642	60	17	0	0	0	0	5
5	Alma East Extension, *Crawford*	1924	0	700	0	0	1,897	19	7	0	0	1	0	5
6		1924	0	400	0	0	1,253	7	4	0	0	0	0	4
7		1926	0	200	0	0	202	0	2	0	0	1	0	0
8		1926	0	100	0	0	442	12	1	0	0	0	0	1
9	Beverly, *Sebastian and Franklin*	1937	0	y	0	0	1,106	124	5	0	0	0	0	3
10	Clarksville, *Johnson*	1926	0	1,600	0	0	28,147	2,695	12	0	0	0	0	10
11			0	y	0	0	333	0	y	0	0	0	0	y
12			0	y	0	0	1,144	937	y	0	0	0	0	y
13			0	y	0	0	1,956	91	y	0	0	0	0	y
14			0	y	0	0	1,082	277	y	0	0	0	0	y
15			0	y	0	0	7,122	396	y	0	0	0	0	2
16			0	y	0	0	929	39	y	0	0	0	0	3
17			0	y	0	0	3,393	169	y	0	0	0	0	y
18			0	y	0	0	9,437	399	y	0	0	0	0	y
19			0	y	0	0	2,751	387	y	0	0	0	0	y
20	Coal Hill, *Johnson*	1930	0	200	0	0	381	27	2	0	0	0	0	y
21	Ewing, *Sebastian*	1936	0	600	0	0	366	78	4	0	0	0	0	y
22			0	y	0	0	204	44	y	0	0	0	0	y
23			0	y	0	0	162	34	y	0	0	0	0	y
24	Greenwood Junction,[1] *Crawford*	1927	0	1,000	0	0	728	5	7	0	0	0	0	6
25	Kibler, *Crawford*	1915	0	4,500	0	0	24,652	138	40	0	y	0	0	14
26			0	y	0	0	y	134	y	0	y	0	0	13
27			0	y	0	0	y	4	y	0	y	0	0	1
28	Lavaca, *Sebastian*	1921	0	1,600	0	0	2,444	365	18	0	0	0	0	14
29		1921	0	y	0	0	328	73	8	0	0	0	0	5
30		1928	0	y	0	0	2,116	292	10	0	0	0	0	9
31	Mansfield, *Sebastian*	1902	0	2,800	0	0	3,184	25	10	0	0	5	0	3
32	Mazzard Prairie, *Sebastian*	1904	0	5,000	0	0	33,446	224	89	0	0	1	0	49
33	Ozark, *Franklin*	1930	0	1,000	0	0	3,557	641	11	0	0	2	0	9
34		1930	0	y	0	0	1,424	226	4	0	0	0	0	4
35		1937	0	y	0	0	1,509	349	4	0	0	2	0	2
36		1938	0	y	0	0	624	66	3	0	0	0	0	3
37	Section 10 field, *Crawford*	1920	0	500	0	0	1,758	50	4	0	0	0	0	3
38	Shibley, *Crawford*	1926	0	400	0	0	1,855	98	6	0	0	0	0	5
39	(Northwest of fault)	1926	0	200	0	0	801	18	3	0	0	0	0	2
40	(Southeast of fault)	1927	0	200	0	0	1,054	80	3	0	0	0	0	3
41	Silex, *Pope*	1942	0	500	0	0	65	65	0	1	0	0	0	1
42		1942	0	y	0	0	0	y	0	1	0	0	0	1
43		1942	0	y	0	0	0	y	0		0	0	0	
44		1942	0	y	0	0	0	0	0	0	0	0	0	0
45	Tate Island, *Pope*	1929	0	500	0	0	2,744	463	3	0	0	0	0	3
46	Vesta, *Franklin*	1932	0	440	0	0	1,869	69	9	0	0	0	0	9
47	Williams, *Crawford*	1918	0	6,500	0	0	39,965	527	64	0	0	0	0	24
48			0	y	0	0	433	433	y	0	0	0	0	y
49			0	y	0	0	94	94	y	0	0	0	0	y
	Total			28,340			161,992	5,733	319					173

[1] Field extends into Oklahoma.

[2] All production and reserves figured on 14.4 + 2-lb. base.

[b] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE I.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Gas Reserve,[2] Millions Cu. Ft.	Producing Formation								Deepest Zone Tested to End of 1942	
	Initial	Average beginning of 1942		End 1942	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[i]	Name	Depth of Hole, Ft.
									Top Prod. Zone	Bottoms Prod. Wells				
1	640	220		348	Atoka	Pen	S	*y*	*y*	1,675	*y*	A	Atoka	1,678
2				1,584									Atoka	2,916
3	330	59		981	Atoka (shallow)	Pen	S	*y*	*y*	2,065	*y*	A		
4	425	29		603	Atoka (deep)	Pen	S	*y*	2,600	2,718	118	A		
5				372									Atoka	3,070
6	378	49		184	Atoka (deep)	Pen	S	*y*	2,400	2,500	100	A		
7	300	38		29	Atoka (shallow)	Pen	S	*y*	*y*	1,879	*y*	A		
8	425	115		159	Atoka (Stray)	Pen	S	*y*	*y*	2,433	*y*	A		
9	440	309		2,981	Atoka	Pen	S	*y*	*y*	2,586	*y*	A	Atoka	2,709
10				29,918								A	Hard Sand Crystallized	4,327
11	345	0		0	Atoka (self)	Pen	S	*y*	1,075	1,085	10			
12	550	210		128	Atoka (Bynum)	Pen	S	*y*	1,990	1,998	8			
13	600	360		2,619	Atoka (Hudson No. 1 & 2)	Pen	S	*y*	2,213 2,510	2,245 2,530	32 20			
14	690	*y*		1,450	Atoka (Houston)	Pen	S	*y*	2,440	*y*	*y*			
15	1,000	465		5,164	Atoka (Russell)	Pen	S	*y*	2,742	2,892	150			
16	810	505		1,408	Atoka (Patterson)	Pen	S	*y*	2,995	3,025	30			
17	1,180	645		3,591	Atoka (Qualls)	Pen	S	*y*	3,012	3,361	349			
18	1,125	575		8,801	Atoka (Kelly)	Pen	S	*y*	3,040	3,452	412			
19	1,300	1,000		6,757	Atoka (Cline)	Pen	S	*y*	*y*	3,401	*y*			
20	500	250		383	Atoka	Pen	S	*y*	1,960	1,977	17	A	*y*	5,596
21				2,326	Atoka	Pen	S	*y*	*y*	*y*	*y*	A	Atoka	2,850
22	250	210		1,014	Atoka (shallow)	Pen	S	*y*	*y*	*y*	*y*			
23	275	247		1,312	Atoka (deep)	Pen	S	*y*	*y*	*y*	*y*			
24	210	43		188	Atoka	Pen	S	*y*	*y*	2,380	*y*	A	Atoka	2,380
25				5,812								AF	Atoka	2,775
26	265	51		*y*	Atoka (deep)	Pen	S	*y*	2,285	2,300	15			
27	220	42		*y*	Atoka (shallow)	Pen	S	*y*	1,260	1,278	18			
28				3,578								A	Atoka	3,092
29	285	165		453	Atoka (shallow)	Pen	S	*y*	*y*	*y*	*y*			
30	280	167		3,125	Atoka (deep)	Pen	S	*y*	*y*	1,775	*y*			
31	315	215		6,791	Atoka (4 sands)	Pen	S	*y*	*y*	2,047	225	D	Atoka	2,977
32	245	25		3,830	Atoka (2 sands)	Pen	S	*y*	*y*	2,260	238	A	Atoka	2,502
33				902								A	Atoka, *y*	5,755
34	875	310		658	Atoka (deep)	Pen	S	*y*	3,759	3,791	32			
35	640	*y*		*y*	Atoka (Anderson)	Pen	S	*y*	*y*	2,167	*y*			
36	670	222		244	Atoka (shallow)	Pen	S	*y*	1,760	1,819	59			
37	265	120		1,431	Atoka	Pen	S	*y*	2,437	2,523	86	AF	Atoka	2,596
38				1,236								AF	Atoka	2,596
39	237	24		88	Atoka (shallow)	Pen	S	*y*	1,245	1,298	53			
40	194	108		1,148	Atoka (shallow)	Pen	S	*y*	*y*	2,630	*y*			
41				3,935								A	Atoka	2,830
42	995	995		*y*	Atoka (2500-ft. sand)	Pen	S	26	2,475	2,512	37			
43	995	995		*y*	Atoka (2800-ft.)	Pen	S	26	2,802	2,817	15			
44	900	900		*y*	Atoka (1000-ft.)	Pen	S	*y*	937	997	60			
45	540	397		5,867	Atoka	Pen	S	*y*	*y*	1,040	*y*	A	Atoka	1,319
46	525	229		1,416	Atoka	Pen	S	*y*	*y*	2,380	*y*	A	Atoka	2,900
47				2,196								AF	Atoka	3,500
48	288	53		*y*	Atoka (deep)	Pen	S	18	2,335	2,370	35			
49	237	66		*y*	Atoka (shallow)	Pen	S	*y*	1,435	1,465	30			
				75,094										

through perforations in the lower ten feet of the tubing string, a packer being set above the perforations to separate the Kelly zone from the Patterson zone. This well may be classified as a triple completion.

Past Development

Wells were drilled in search of oil or gas in the vicinity of Fort Smith as far back as the 1880's. In 1887, the first show of gas was encountered in a well drilled with water-well tools within the present city limits of Fort Smith. When a cone-shaped cap with a small opening in the top was placed over the well, enough gas was produced to make a flame about the size of that given off by a small burning candle. This well was located near the present limits of the Mazzard Prairie field.

The first discovery of a commercial deposit of gas was made on the Hartford anticline near the town of Mansfield by Choctaw Oil Company's No. 2 well in the year 1902. Dr. John C. Branner mapped and worked out the surface details of this structure for Harry E. Kelly, president of Choctaw Oil Co. The company's No. 1 well was drilled in 1901, but only a small gas show was encountered in this well; however, this small gas show caused the second well to be drilled in 1902. The gas zone found in the No. 2

Table 2.—*Summary of Drilling Operations in Northwest Arkansas*

Important Wildcats Drilled in Northwest Arkansas

	County	Date of Completion	Location			Total Depth, Ft.	Surface Formation
			Sec.	Tp.	Rge.		
1	Crawford	(?)	20	12 N	31 W	3,765	Atoka
2	Crawford	7-15-41	6	9 N	30 W	6,578	Spadra shale
3	Crawford	4-27-42	22	9 N	31 W	5,104	Ft. Smith formation
4	Franklin	12-24-32	24	10 N	29 W	3,157	Atoka
5	Franklin	3-15-28	19	11 N	27 W	3,700	Atoka
6	Franklin	12-24-30	33	10 N	26 W	3,792	Atoka
7	Franklin	38	8	9 N	26 W	4,032	Atoka
8	Franklin	1-17-42	17	8 N	28 W	2,900	Spadra shale
9	Franklin	10-30-42	31	10 N	26 W	5,755	Atoka
10	Johnson	10-24-22	33	9 N	22 W	3,500	Hartshorne sandstone
11	Johnson	9-13-29	21	9 N	25 W	5,596	Hartshorne sandstone
12	Johnson	8- 5-40	5	9 N	22 W	3,681	Spadra shale
13	Johnson	10-30-40	14	10 N	24 W	4,237	Spadra shale
14	Logan	19	26	5 N	28 W	3,517	Atoka
15	Logan	3-27-29	26	8 N	24 W	4,619	Atoka
16	Logan	10-23-29	26	7 N	23 W	4,170	Atoka
17	Logan	11- 1-42	7	8 N	26 W	2,690	Hartshorne sandstone
18	Pope	20	1	7 N	18 W	1,630	Atoka
19	Pope	22	14	9 N	20 W	3,410	Atoka
20	Pope	4-22-28	7	8 N	21 W	4,053	Hartshorne sandstone
21	Pope	7-31-30	13	9 N	19 W	4,909	Atoka
22	Pope	5- 8-31	11	7 N	20 W	4,234	Atoka
23	Pope	5-22-31	15	9 N	21 W	4,375	Atoka
24	Pope	3- 1-37	10	8 N	21 W	4,800	Atoka
25	Pope	10-23-42	22	10 N	21 W	2,830	Atoka
26	Scott	4-14-30	[illegible]	4 N	30 W	2,977	Atoka
27	Sebastian	8- 1-24	1	7 N	30 W	3,235	Spadra shale
28	Sebastian	5-22-27	16	7 N	32 W	3,460	Spadra shale
29	Sebastian	5-22-27	21	4 N	32 W	4,270	Spadra shale
30	Sebastian	6- 5-28	14	5 N	32 W	4,335	Spadra shale
31	Sebastian	10- 4-30	9	7 N	29 W	3,515	Ft. Smith formation
32	Sebastian	12- 1-37	21	7 N	30 W	5,940	Hartshorne sandstone
33	Yell		28	4 N	22 W	3,768	Atoka
34	Yell	9-14-15	15	5 N	24 W	3,095	Atoka
35	Yell	21	21	4 N	24 W	2,631	Atoka
36	Yell	25	3	5 N	22 W	2,526	Atoka
37	Yell	2-18-32	36	7 N	21 W	3,550	Atoka
	Total						

well was not thought to be of commercial value and the gas from this well was allowed to escape into the air for about two years. In 1903, the well was completed for an initial production of 550,000 cu. ft. per day with a rock pressure of 315 lb. per sq. in. This well was produced continuously up until about 1940 and has been temporarily shut in since that time. The present pressure on this well is about 200 lb. per sq. in. and the well is capable of producing about 250,000 cu. ft. per day.

The discovery of commercial gas deposits in Arkansas in 1902 was followed in 1904 by the discovery of the large Mazzard Prairie field by the Mansfield Gas Co., successor to the Choctaw Oil Co. Fort Smith largely owes its present industrial status to the discovery of the Mazzard

TABLE 2.—(*Continued*)

Important Wildcats Drilled in Northwest Arkansas

	Deepest Horizon Tested	Drilled by	Initial Production per Day		Pressure, Lb. per Sq. In.		Remarks
			Oil, U. S. Bbl.	Gas, Millions Cu. Ft.	Casing	Tubing	
1		Ashby, Pat	0	0			Dry
2	Sand, (*y*)	Industrial Oil & Gas Co.	0	0.025	*y*	*y*	Plugged back to shallow zone
3	Sand, (*y*)	Industrial Oil & Gas Co. and Darby Petr. Corp	0	0			Plugged and abandoned
4		Duncan & O'Bryant	0	0			Dry
5	Sandy lime	Ark. Nat. Gas Corp.	0	0			Dry
6		Red Bank Oil Co.	0	0			Dry
7	Black sand	Ozark Nat. Gas Co.	0	0			Dry
8	Shale	Ozark Nat. Gas Co.	0	0			Plugged and abandoned
9	Sand	Ozark Nat. Gas Co.	0	0			Dry
10		Piney Oil & Gas Co.	0	0			Dry
11		Blackwell Oil & Gas Co.	0	0.5	*y*	*y*	
12	Hard sand	Industrial Oil & Gas Co.	0	0			Plugged and abandoned
13	Sand (hard crystallized)	Ark.-La. Gas Co.	0	5.5	*y*	*y*	Plugged back to shallow zon
14		Red River Oil & Gas Co.	0	0			Dry
15		Ark.-La. Pipe Line Co.	0	0			Dry
16		Ark.-La. Pipe Line Co.	0	0			Dry
17	Shale	Ozark Nat. Gas Co.	0	0			Plugged and abandoned
18		Quinton Oil & Gas Co.	0	0			Dry
19		Muskogee Oil Co.	0	0			Dry
20		Nat. Gas & Fuel Corp.	0	0			Dry
21		Cosden Oil Co. of Ark.	0	0			Abandoned
22		Ark.-La. Pipe Line Co.	0	0			Dry
23	Black sand	Ark.-La. Pipe Line Co.	0	0			Dry
24	Shale	Ark.-La. Gas Co.	0	0			Abandoned
25	3rd sand (Atoka)	Ark.-La. Gas Co.	0	26	995	995	Opens Silex field
26		Mansfield Gas Co.	0	0			Dry
27	Black lime	Panuco Exploration Co.	0	0.25			Abandoned
28	Shale (brown)	Athletic Mining & Smelting Co.	0	0			Dry
29		Central Coal & Coke Co.	0	0			Dry
30	Shale	Athletic Mining & Smelting Co.	0	0			Dry
31		Greeson, M. W.	0	0			Dry
32	Sandy lime	Ozark Nat. Gas Co.	0	0			Dry
33		Delatta Well No. 56	0	0			Abandoned
34		Schaffer, C. B.	0	0			Abandoned
35		Coleman, Ed.	0	0			Abandoned
36		Ran Dan Oil Co.	0	0			Abandoned
37	Sandy shale	Tegmeir-Luckett (Falcon)	0	0			Abandoned
				32.275			

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	1	1
Number of oil wells completed during 1942	0	0
Number of gas wells completed during 1942	0	1
Number of dry holes completed during 1942	2	4

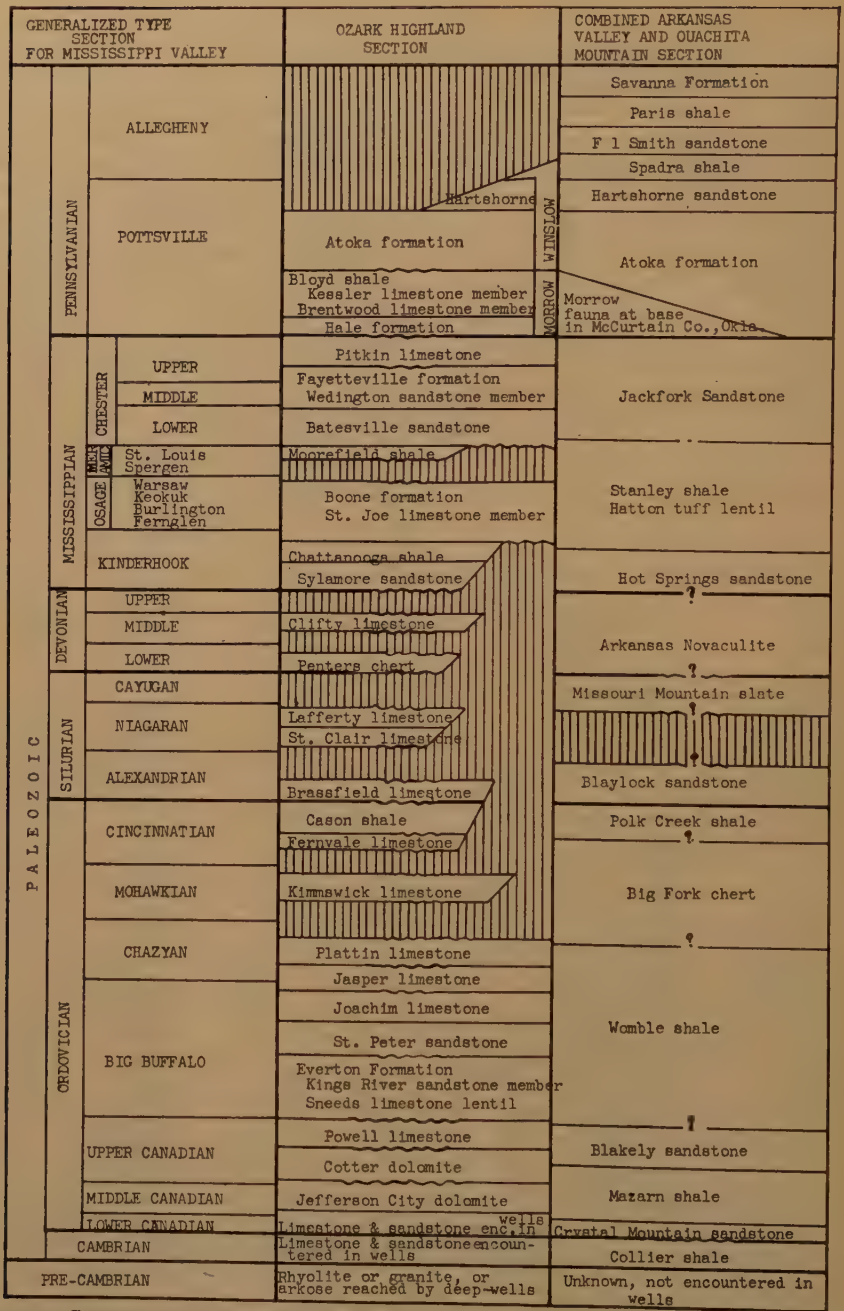

FIG. 3.—CORRELATION BETWEEN GENERALIZED TYPE SECTION FOR THE MISSISSIPPI VALLEY, THE OZARK HIGHLAND REGION, AND THE COMBINED ARKANSAS VALLEY AND OUACHITA MOUNTAIN REGION. (*After Carey Croneis.*)

Prairie field so near the city. This field covers about 5,000 acres and is still producing a considerable quantity of gas.

Soon after the discovery of Mazzard Prairie, several gas-consuming industries were established in Fort Smith and near-by towns. Notable examples among these industries are zinc smelting and glass manufacture. Zinc ore is imported from states several hundred miles distant and the gas is used to separate the zinc from the ore. The fact that it is much cheaper to transport the ore to the gas-producing area than to transport the gas to the zinc-producing area made it possible for the establishment of these industries in northwestern Arkansas. Natural gas is providing full exploitation of the amazing variety of minerals found in Arkansas.

VARIETY OF MINERALS

Arkansas supplies about 98 per cent of the domestic aluminum ore at present. Closely following in importance to the war effort are the deposits of manganese. The ore bearing this metal, used principally in the manufacture of ferromanganese and other wear-resistant steel alloys such as those used to armor-plate our battleships and tanks, is mined in three districts, Batesville, Glenwood and from mines in Montgomery County.

Zinc and lead deposits are in the north central part of the state in seven joining counties. Many small-scale operations in the zinc-mining district were begun a year ago when the demand for this metal became large.

Mercury is another important mineral contribution to the victory effort. It is being mined in Pike and Howard Counties. The metal is extracted from the cinnabar ore through a simple process requiring small capital and few workmen. The most important war use of mercury is in the manufacture of mercury fulminate, which is the basis of most detonating compositions for high explosives.

Among the next most important metallic minerals is titanium. Three titanium minerals have been found in large quantities—rutile, brookite and ilmenite. The principal use of rutile is in the manufacture of a coating for welding rods. It also is used in the manufacture of titanium tetrachloride for making smoke screens such as are employed by warships. The metal is also used for purifying steel and is added to some steels to make them more easily rolled while hot. When the present mining projects are completely developed, Arkansas will be the leading producer in the nation of titanium, the source of which before the war was the Far East.

INCREASING DEMAND

Fig. 1 shows that the yearly production of natural gas in northwestern Arkansas has been on an upward trend for the past five years. This increased production was necessarily brought on by an increase in demand due to the present national emergency and also because of a decrease in Oklahoma gas production available to Arkansas industry.

REMAINING RESERVES

The remaining reserves as of Jan. 1, 1943, as shown on Fig. 1, were approximately 75 billion cubic feet. This reserve was calculated on a pressure-decline-volumetric basis and represents the available reserve taken down to atmospheric pressure. The fields will perhaps be abandoned above that pressure, but the past history of production in northwestern Arkansas has shown that more gas has been produced per pound drop in reservoir pressure during the latter part than during the early part of the life of a field. This latter fact will probably offset the reserve lost by higher abandonment pressures. If abandonment pressure was raised to a gauge pressure of 15 lb. per sq. in., about 7 billion cubic feet must be deducted from the above figure leaving a reserve of 68 billion cubic feet. Breaking up of the above mentioned 75 billion reserve into reserves for each pool is given in Table 1 under the column headed "Gas Reserves, End 1942." Table 1 also lists other data on gas fields in northwestern Arkansas while Fig. 2 shows the location of these fields.

WILDCATTING

Table 2 gives a list of most of the important dry holes drilled since 1900. Wildcats resulting in the discovery of new fields up to January 1, 1942, are not listed.

PROSPECTIVE DEVELOPMENTS IN 1943

The new Silex discovery, Arkansas Louisiana Gas Company's Ladd & Strong No. 1, in the SW.¼ of the SW.¼ of sec. 22, T. 10 N., R. 21 W., Pope County, was completed Oct. 23, 1942. Initial production was 26,000,000 cu. ft. per day. This production came from two zones; namely, the second sand at 2475 to 2514 ft. and the third sand at 2802 to 2817 ft. The second and third sands were perforated with 350 and 97 shots, respectively. The upper zone produced at an initial rate of 17,263,000 cu. ft. per day through the annular space between the tubing and 10¾-in. casing strings. The lower zone produced at an initial rate of 9,562,000 cu. ft. per day through the tubing. Rock pressures were 900 and 975 lb. per sq. in., respectively. Porosity of the lower two zones averages 26 per cent. Another productive zone was found at 937 to 997 ft., which was estimated to be capable of producing 25 million cubic feet per day. C. R. McKnight, Arkansas Louisiana Gas Co., estimates that the recoverable reserve per well for wells drilled in the new Silex field will be about 1,500,000,000 cubic feet per well. The Silex structure is a long narrow structure and several wells will probably be completed on this anticline during the year 1943. The discovery well in this field was drilled with cable tools.

In 1943, some wildcats will probably be drilled in and near Pope County. Several untested anticlines are present in this vicinity and the Silex discovery in that county, along with increasing war-time markets for natural gas, will probably act as an incentive for wildcatters to renew their search for gas in near-by structures.

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Developments in the California Oil Industry during 1942

By V. H. Wilhelm,* Member A.I.M.E.

Developments in California during 1942 were marked by many difficulties in operation, of which the lack of labor and material were the main factors in slowing down work. During the many years of curtailment, which has been effective since 1928, a number of estimates of the state's capacity to produce have been built up, but during the year 44 fields were eliminated from curtailment and valuable data were obtained as to the normal capacity of these fields to produce. Because of new discoveries and the normal decline of old fields, which is more than 15 per cent per year, it is estimated that the sustained capacity of the state for a 5-year period is not more than 500,000 bbl. per day.

Decline in the rate of production was greatest in the fields in the Los Angeles Basin district. These fields have been produced nearly at capacity for many years and had no reserve of shut-in production. The San Joaquin Valley and Coastal districts have responded well to the increased allotments assigned to them by the Petroleum Administrator for War. All heavy oil fields in the state are on full production, except in the Coastal district, where transportation is the limiting factor.

Although approximately 2500 more wells are on production in the state than there were in 1941, the supply of heavy crude has not yet reached the demand.

A summary of statistics for 1941 and 1942 is given in the following table.

Statistics for 1941 *and* 1942 (*Estimated*)

	1941	1942
Number of new wells	942	566
Average initial potential of new well, bbl.	1,107[a]	296[b]
Crude production, avg. bbl. per day	631,000	680,000
Crude allotment, avg. bbl. per day	590,700	680,100
Demand in terms of crude, avg. bbl. per day	649,700	711,000
Discoveries for entire year, bbl.	22,000,000	25,000,000

[a] Based on initial potential tests.
[b] Estimated six-months efficient maximum production.

Production

Production in California for 1942 was 680,000 bbl. a day as against 631,000 bbl. a day for 1941, an increase of 7.8 per cent. The present maximum efficient rate has been estimated at 808,000 bbl. per day. This indicates that in the 15 restricted fields of the state there is only an additional 83,000 bbl. per day of light oil available.

Drilling Activity

Drilling activity during the year was equivalent to but 70 per cent of normal. Although shortages of equipment and labor were in part responsible for the reduced drilling activity, the main reasons were the lack of proved locations due to a cycle of very few new discoveries and the restrictions of Conservation Order M-68.

For the first six months of the year, 300 new oil wells were completed, which were equally divided as to the number of light and heavy oil producers. But, for the last six months of the year, it is

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The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.

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expected that deep drilling for light oil will decline considerably because of the lack of demand and material, and drilling will be concentrated on present heavy oil fields where a minimum of steel will be needed per barrel of settled production obtained.

The San Joaquin Valley district was the area of the greatest drilling activity, the South Belridge field being the most active in the state. Settled production of 50 to 75 bbl. per day of 13° gravity oil is being obtained in this field from a depth of 800 ft. There were 93 new wells completed in this field during the year, which added 4,400 bbl. per day of new production to the state.

More than one fourth of the 3-billion-barrel reserve of the state is heavy oil of 24° gravity or less. The recovery rate of this oil, nevertheless, is very slow, therefore it will be necessary to drill an increasing number of heavy oil wells to meet the increasing demands.

NEW DISCOVERIES

San Joaquin Valley District

Paloma Field.—Paloma field was extended one mile to the north by the completion of General Petroleum Corporation's Gallagher No. 61-33 well, for 648 bbl. per day of 34.3° gravity oil, together with 648,000 cu. ft. of gas. Production is from 40 ft. of sand with bottom at 11,043 ft. This extension will add 800 acres to the Unit Plan formed in the field to recycle gas produced from the condensate zone. Other wells completed in the Paloma field have produced gas with a condensate oil testing from 40° to 56° gravity. However, this discovery indicates that the Paloma field may have a black-oil belt around the lower contours of the structure.

East Strand Field.—In the East Strand field, Tide Water Associated Oil Co. has discovered a new field of limited extent, with the completion of its KCL No. 56-8 well, sec. 8, T. 30 S., R. 26 E., flowing 1523 bbl. per day of 33.8° gravity oil and 1250 M cu. ft. of gas. This well is one mile east of the Strand field and is producing from the Stevens sand.

Helm Field.—Amerada Petroleum Corporation has extended its Helm field one mile to the northwest by the completion of its Truman 4-6 well for 120 bbl. per day of distillate, together with 2236 M cu. ft. of gas from a depth of 8295 ft. Approximately 1000 acres were added to the productive area of this field.

Belridge Area.—The Shell Oil Co. discovered a new heavy oil field 3½ miles southwest of the North Belridge field. The discovery well, Williams 45-6, flowed 925 bbl. per day of 16.4° gravity oil from a depth of 2340 ft. The structure is a plunging nose with a probable productive area of 260 acres. Production is from 60 ft. of Miocene sand.

E. A. Parkford completed Parkford No. 2 well ¾ mile southeast of the South Belridge field, for 70 bbl. of 14° gravity oil from a depth of 1695 ft. Production is from overlapping sands of Tulare (Pliocene) age.

Coastal District

Newhall-Potrero Field.—The entire proved acreage of the Newhall-Potrero field until 1942 was controlled by the Barnsdall Oil Co., which discovered it. During the year the limits of this field were extended to the south and to the north. Two hundred acres to the south were proved by the completion of the C. G. Willis well, Ferguson No. 1, which flowed 200 bbl. of 34° gravity oil from a depth of 7020 ft. This well is on the south side of an east-west fault, which was considered to be the limit of production at the south side of the field. On the northwest plunge of the field, The Texas Company proved 260 acres by bringing in well Newhall No. 1 for 350 bbl. of 30.6° gravity oil from a depth of 7878 ft. This well is 2700 ft. northwest of the nearest production.

TABLE 1.—*Oil and Gas Production in California*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
	SAN JOAQUIN VALLEY					
1	Belridge, North, *Kern*	1912	1,930		45,609,089	1,946,800
2	South, *Kern*	1911	3,970		24,037,135	954,045
3	Buena Vista, *Kern*	1909	22,000		287,443,392	5,296,479
4	Canal, *Kern*	1937	940		7,643,162	1,060,294
5	Coalinga, East, *Fresno*	1900	6,400		226,639,957	5,234,013
6	West, *Fresno*	1900	11,370		148,405,118	2,102,003
7	Nose, *Fresno*	1938	3,030		21,685,540	8,464,809
8	Northeast, *Fresno*	1939	1,225		8,566,830	3,488,560
9	Coles Levee, *Kern*	1938	2,930		5,380,502	1,458,565
10	Edison, *Kern*	1934	1,695		9,326,582	1,006,399
11	Elk Hills, *Kern*	1919	10,000		162,100,305	4,362,900
12	Fruitvale, *Kern*	1928	2,050		26,620,172	2,269,322
13	Greeley, *Kern*	1936	2,200		9,039,994	2,594,249
14	Helm, *Kern*	1941	2,000		82,900	80,448
15	Jacalitos, *Kern*	1941	160		59,961	56,730
16	Kern Front, *Kern*	1925	3,975		49,970,664	2,409,395
17	Kern River, *Kern*	1899	6,700		280,354,235	2,667,076
18	Kettleman North, *Kern and Fresno*	1928	16,720		265,216,284	13,017,780
19	Lost Hills, *Kern*	1910	2,560		52,693,058	1,381,844
20	McKittrick, *Kern*	1887	1,525		94,152,732	1,781,501
21	Midway-Maricopa, *Kern*	1901	32,480		645,392,646	15,107,601
22	Mountain View, *Kern*	1933	2,430		42,144,821	1,763,441
23	Mt. Poso District, incl. Poso Creek, *Kern*	1926	3,775		66,300,055	8,007,728
24	Paloma, *Kern*	1939	3,420		481,139	272,197
25	Raisin City, *Fresno*	1941	320		363,442	301,911
26	North Cotes Levee, *Kern*	1938	3,000		8,890,661	3,978,480
27	Rio Bravo, *Kern*	1937	2,140		16,296,315	3,574,502
28	Riverdale, *Fresno*	1941	2,500		93,141	91,385
29	Round Mountain, incl. Coffee Canyon, *Kern*	1927	1,710		34,624,804	3,886,979
30	Shafter, *Kern*	1941	40		34,849	21,260
31	Strand, *Kern*	1939	320		1,643,298	427,944
32	Ten Sections, *Kern*	1936	2,260		20,390,261	4,804,810
33	Wasco, *Kern*	1938	360		2,175,069	450,196
34	Wheeler Ridge, *Kern*	1922	300		4,019,324	98,734
35	Williams (Antelope Plains), *Kern*	1942	260		91,099	91,099
36	Others				1,060,985	116,311
37	San Joaquin, total				2,569,029,521	104,627,790
	COASTAL DISTRICT				82,357,928	1,782,829
38	Capitan, *Santa Barbara*	1929	296		6,490,651	843,718
39	Elwood, *Santa Barbara*	1928	480		69,291,719	876,065
40	Santa Barbara, *Santa Barbara*	1929	165		3,412,501	58,361
41	Summerland, *Santa Barbara*	1894	180		3,163,057	4,685
	Santa Maria District				180,525,937	11,458,860
42	Casmalia, *Santa Barbara*	1904	1,010		[1]	98,855
43	Cat Canyon, *Santa Barbara*	1908	1,480		[1]	1,038,661
44	Gato Ridge, *Santa Barbara*	1931	440		6,794,052	1,214,441
45	Lompoc, *Santa Barbara*	1903	2,735		[1]	417,987
46	Orcutt, *Santa Barbara*	1903	4,220		[1]	1,166,379
47	Santa Maria Valley, *Santa Barbara*	1934	5,610		29,672,046	7,522,537
	Ventura District					
48	Padre Canyon, *Ventura*	1936	180		2,077,499	370,617
49	Rincon, *Ventura*	1927	425		15,090,130	1,007,148
50	San Miguelito, *Ventura*	1931	430		7,087,700	1,219,670
51	Ventura Avenue, *Ventura*	1916	2,060		252,312,035	13,651,864
	Ventura-Newhall District				71,303,694	3,687,752
52	Bardsdale, *Ventura*	1894	287		[2]	55,269
53	Del Valle, *Los Angeles*	1940	370		1,243,012	516,390
54	Ex-Mission, *Ventura*	1875	130		[2]	11,769
55	Hopper Canyon, *Ventura*	1887	153		[2]	44,501
56	Modelo, *Ventura*	1898	60		[2]	3,534
57	Newhall Potrero, *Los Angeles*	1937	550		3,581,463	1,306,673
58	Oak Canyon, *Los Angeles*	1941	240		201,058	153,243
59	Oxnard, *Ventura*	1937	490		[2]	191,655

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] With Santa Maria district.

[2] With Ventura Newhall district.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil			
				During 1942		End of 1942			Number of Wells					Gravity A.P.I. at 60°F., Weighted Average			Sulphur, Per Cent
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942					
1	320,895	21,008		3		67	60		40	20	2,300 3,750	1,700 1,600		42	28	34.5	0.25
2				93		63	286		1	285				26	14	24	
3	With Midway-Maricopa			21		136	781			781				29	22	26.6	0.59
4	With Strand			1		4	35		26	9	3,550	1,600	R	38	36	37.5	0.70
5	24,585	6,346		23	2	128	494			494				22	19	21.0	0.67
6				10	7	63	670			670				23	12	15.8	0.45
7				11		4	164		161	3	3,450	3,000		34	28	33	0.40
8				1		11	49		47	2	3,740	3,000		54	27	28	0.24
9	33,008	14,363		13		1	53		52	1	4,300	3,600	PM	34	28	33	0.90
10				1		6	112		1	111				26	15	18.5	0.75
11	81,643	1,232		3		53	209		1	208				25	15	22.1	0.57
12				1	1	19	167		14	153				24	14	19.8	0.60
											3,200	1,750					
13	18,798	1,841		10	1	1	78		66	12	4,890	3,700		60	32	38.5	0.28
14		5,196		8		3	6		6					35	65	65	0.02
15				5			6		2	4						40	0.48
16				10	1	17	455			455				15	12	14.4	1.29
17				3	1	383	1,923			1,923				14	12	13.3	1.07
18	1,579,564	89,007		13	1	77	261		108	153	3,200 4,500	2,000 3,900		37	34	36.5	0.30
19				3	5	35	366			366				36	13	18	0.99
20				2		53	282		1	281				22	12	14.2	1.02
21	387,986	12,396		46	11	299	2,474		1	2,473				28	12	17.5	0.75
22	50,206	1,218		1	4	16	159			159				31	20	26	0.66
23				37	1	17	507			507				15	12	13.8	0.71
24				3		7	3		3				R	48	55	51	
25		143		4		1	10		10					36	24	30	0.16
26	With Coles Levee					5	74		73	1	3,700		R	33	45	40	0.85
27	17,569	4,582		2		2	98		98		4,750	3,700		40	37	38.5	0.32
28				12		1	12		12					45	32	35	
29				12	1	11	246			246				17	13	16.5	
30				1			2			2						37	0.20
31	9,133	2,422		2		1	14		14		3,600			35	38	35	0.37
32	32,237	8,956		5		10	114		110	4	3,550	3,000		38	34	35.4	0.04
33						1	12		9	3	5,670	5,400				38	0.26
34					1		34			34				23	24	23.5	
35				11		1	10		7	3				16	17	16.6	0.77
36				4	2	43	15			15							
37	2,555,624	168,710		374	34	1,539	10,241		863	9,378							
						26	139		2	137							
38	3,840	326			1	7	51			51				43	18	28	
39	64,817	1,757				17	64		2	62				41	22	33.7	
40						1	21			21				19	14	17	0.30
41						1	3			3				19	17	18	0.54
						141	510		48	462							
42				1		53	1			1				21	8	10.3	2.84
43				5		43	31		5	26				16	10	13.5	4.13
44				3		2	21			21				14	13	13.9	5.42
45						8	28		5	23				21	20	20.5	4.4
46				1		35	196			196				26	18	22.6	2.63
47	7,566	4,259		28	1	7	233		38	195	1,750			17	13	15.9	4.64
						74	524		208	316							
48	18,684	1,598				4	20		2	18	2,400	1,000		31	28	29.1	
49							72		12	60				31	27	30	
50	9,401	1,813		4		1	26		25	1	2,720	2,100		34	29	30	
51	845,255	34,381		17		69	406		169	237	2,750			50	12	30	0.73
						196	583		52	531							
52					6	9	26		1	25				33	22	32.1	0.83
53				8		2	18		16	2	2,500	2,100				32	1.21
54						1	23			23				28	18	25.2	0.70
55							14			14				31	18	29	
56					3	4	12			12				26	26	26.1	
57				8		3	30		30		3,200	2,600		35	33	33.3	0.54
58				3			5		4	1				34	23	33	0.83
59							3			3				8	8	8	

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
1	Etchegoin, Temblor, Vaqueros	Pli, Mio	S	14	4,917	7,152	625	A	Cretaceous	10,800
2	Etchegoin, Temblor	Pli, Mio	S		800	874	50	A	Miocene	11,377
3	San Joaquin Clay, Etchegoin	Pli	S	25	2,665	3,500	50	A	Miocene	14,622
4	Stevens	Mio	S	22	8,250	8,297	160	A	Miocene	13,400
5	Etchegoin, Temblor	Pli, Mio	S	25	1,860	2,076	170	AUP	Cretaceous	9,418
6	Etchegoin, Sta. Margarita	Pli, Mio	S		900	1,580	180	MUP	Cretaceous	4,883
7	Avenal	Eoc	S	19	6,400	7,843	360	MU	Eocene	8,416
8	Avenal	Eoc	S	23	7,980	8,226	130	MU	Cretaceous	9,614
9	Stevens	Mio	S	20	8,070	9,621	200	MU	Miocene	10,101
10	Kern River, Temblor	Pli, Mio	S		2,000	2,239	125	MU	Granite	800
11	San Joaquin Clay, Etchegoin, Stevens	Pli, Mio	S	38	2,600	3,115	75	A	Miocene	11,177
12	Etchegoin, Chanac	Pli	S		3,000	3,685	88	MU	Schist-Jurassic	10,590
13	Stevens, Vedder	Mio	S	21	11,430	11,530	290	AM	Lower Miocene	12,504
14	Temblor, Eocene	Mio, Eoc	S	30	7,300	7,465	50	A	Cretaceous	10,257
15	Temblor	Mio, Eoc	S		3,865	3,905	11	AF	Cretaceous	6,031
16	Etchegoin	Pli	S			2,175	80	MF	Jurassic slate	6,211
17	Kern River	Pli	S		400	837	130	MU	Oligocene	4,852
18	Temblor, Avenal	Mio, Eoc	S	15	6,300 10,200	8,266 10,848	850	A	Cretaceous	12,884
19	Etchegoin	Pli	S		1,170	1,204	80	A	Miocene	7,858
20	Etchegoin	Pli	S		800	1,107	350	MUF	Miocene	6,664
21	Etchegoin, Maricopa	Pli, Mio	S		1,950	2,095	65	MUF	Miocene	10,410
22	Chanac, Sta. Margarita	Pli, Mio	S		6,080	6,165	55	MF	Granite	8,624
23	Vedder	Mio	S	35	1,600	1,745	150	MF	Granite	3,130
24	Stevens	Mio	S	20	10,140	10,376	200	A	Miocene	11,811
25		Mio	S		5,040	5,090	10	A	Eocene	6,429
26	Stevens	Mio	S	20	8,990	9,580	320	MU	Miocene	10,120
27	Vedder	Mio	S	22	11,249	11,491	220	A	Schist-Jurassic	14,108
28	Miocene, Eocene		S		6,500	6,685	35	AU	Slate-Jurassic	11,990
29	Jewett, Vedder	Mio	S	34		1,861	66	MF	Oligocene	6,070
30	Vedder	Mio	S		12,800	12,890		A	Miocene	12,934
31	Stevens	Mio	S	23	8,320	8,432	115	D	Miocene	12,818
32	Stevens	Mio	S	20	7,850	8,219	200	A	Miocene	10,023
33	Vedder	Mio	S	15	13,100	13,143	25	A	Eocene	15,004
34	Etchegoin, Sta. Margarita	Pli, Mio	S		2,000	2,717	40	A	Oligocene	11,204
35	Miocene	Mio	S	30	2,200	2,600	60	AU	Oligocene	3,584
36										
37										
38	Vaqueros, Sespe	Mio, Olig	S		1,150	1,400 2,734	135	AF	Sespe	4,071
39	Monterey, Vaqueros, Sespe	Mio, Olig	S	25	2,800	3,128 3,906	330	AF	Eocene	7,151
40	Vaqueros	Mio	S		1,960	2,003	75	MF	Sespe	4,730
41	Pliocene, Vaqueros	Pli, Mio	S		400	1,600	225	A	Sespe	5,041
42	Sisquoc, Monterey	Mio	H		1,200	1,679	Fis	A	Miocene	3,900
43	Sisquoc	Mio	S & H		2,000	3,000	Fis	A	Cretaceous	7,199
44	Sisquoc, Monterey	Mio	H		1,800	3,255	Fis	AF	Vaqueros, Miocene	6,510
45	Sisquoc, Monterey	Mio	S & H		2,200	2,711	Fis	A	Miocene	4,310
46	Sisquoc, Monterey	Mio	S & H		1,100	3,175	Fis	A	Sespe, Oligocene	5,915
47	Monterery	Mio	S & H		4,000	4,488	Fis	MU	Franciscan	8,133
48	Pico, Repetto	Pli	S		4,800	5,929	140	AF	Miocene	6,751
49	Pico, Repetto	Pli	S		2,500	3,812	140	A	Pliocene	10,515
50	Pico, Repetto	Pli	S		5,500	6,903	680	AF	Pliocene	10,030
51	Pico, Repetto	Pli	S		3,400	6,244 7,188 9,240	3,000	A	Pliocene	11,516
52	Sespe, Tejon	Olig, Eoc	S		500	888	y	A	Eocene	6,804
53	Modelo	Mio	S	28	6,037	6,142	107	A	Miocene	9,850
54	Repetto	Pli	S		500	1,585	y	MF		
55	Modelo	Mio	S		1,500	1,828	y	A		2,200
56	Modelo	Mio	S		180	2,050	y	A		1,488
57	Modelo	Mio	S		6,160	6,787	230	AF	Miocene	8,120
58	Modelo	Mio	S	22	2,365	7,288	80	A	Miocene	8,090
59	Modelo	Mio	S		2,100	2,905	y	MU	Miocene	4,285

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
60	Pico Canyon-Newhall, *Los Angeles*	1875	110		[2]	26,203
61	Sespe, incl. Topa-Topa, *Ventura*	1887	289		[2]	81,192
62	Shiells Canyon, *Ventura*	1911	510		[2]	344,030
63	Simi, *Ventura*	1912	635		[2]	26,820
64	Sisar-Silverthread, *Ventura*	1885	330		[2]	46,012
65	South Mountain, *Ventura*	1916	785		[2]	537,630
66	Tapo-Eureka, incl. Holser, *Ventura*	1882	224		[2]	15,617
67	Temescal, *Ventura*	1924	120		[2]	253,532
68	Timber Canyon, *Ventura*	1885	110		[2]	10,348
69	Fresno-Lion Mt., *Ventura*	1917	50		[2]	6,411
70	Torrey Canyon, *Ventura*	1896	140		[2]	54,054
71	Wiley-Towsley Canyon, *Ventura*	1887	28		[2]	2,869
	Other Coastal Counties				1,276,487	14,146
72	Edna, *San Luis Obispo*	1929	25		747,179	5,477
73	Pismo, *San Luis Obispo*	1928	200		104,445	
74	Half Moon Bay, *San Mateo*	1886	80		41,477	
75	Sargent, *Santa Clara*	1886	60		383,386	8,669
76	Coastal District, Total		27,175		612,031,410	33,192,886
	LOS ANGELES BASIN					
77	Alamitos, *Los Angeles*	1931	200		24,462,263	322,025
78	Aliso, *Los Angeles*	1938	450		2,423,173	714,609
79	Brea Olinda, *Orange*	1889	1,680		171,598,585	3,704,660
80	Buena Park, *Orange*		100		38,661	38,661
81	Coyote, East, *Orange*	1911	1,160		45,633,310	2,036,958
82	West, *Orange*	1909	985		129,229,988	3,783,486
83	Dominguez, *Los Angeles*	1923	1,200		138,174,487	7,920,136
84	El Segundo, *Los Angeles*	1935	930		10,560,498	423,890
85	Huntington Beach, *Orange*	1920	2,200		312,991,480	11,980,255
86	Inglewood, *Los Angeles*	1924	1,075		132,436,393	6,742,308
87	Lawndale, *Los Angeles*	1928	72		1,080,063	9,463
88	Long Beach, *Los Angeles*	1921	1,600		676,641,896	12,977,542
89	Los Angeles dist., *Los Angeles*	1892	1,627		66,223,123	191,300
90	Montebello, *Los Angeles*	1917	1,750		131,173,963	3,924,502
91	Playa Del Rey, *Los Angeles*	1934	670		48,685,361	1,197,233
92	Potrero, incl. Kraemar-Puente, *Los Angeles*	1928	220		4,594,288	317,628
93	Richfield, *Orange*	1919	1,370		97,052,879	2,751,387
94	Rosecrans-Athens, *Los Angeles*	1924	850		50,882,752	2,700,415
95	Santa Fe Springs, *Los Angeles*	1919	1,630		484,931,079	7,756,155
96	Seal Beach, *Los Angeles*	1926	310		68,390,251	2,695,166
97	Torrance, *Los Angeles*	1922	6,200		107,217,386	2,993,362
98	Turnbull Canyon, *Los Angeles*	1941	80		123,202	111,277
99	Whittier, *Los Angeles*	1898	600		18,796,367	378,298
100	Wilmington, *Los Angeles*	1935	4,400		173,468,680	33,447,469
101	Others				1,038,183	193,234
102	Los Angeles Basin, total				2,897,848,311	109,311,419
103	STATE TOTAL				6,078,909,242	247,132,095
	GAS FIELDS					
	NORTHERN GROUP					B.t.u. of Gas
1	Eureka, *Humboldt*	1937		520		1,040
2	McDonald Island, *San Joaquin*	1936		1,885		980
3	Potrero Hills, *Solano*	1938		100		991
4	Rio Vista, *Sacramento and Solano*	1936		25,000		1,040
5	Sutter Buttes, *Sutter*	1936		2,000		1,000
6	Tracy, *San Joaquin*	1935		620		935
7	Willows, *Glenn*	1938		200		990
8	Fairfield Knolls, *Yolo*	1937		120		945
9	Petaluma, *Sonoma*	1941		40		1,002
10	Vernalis, *San Joaquin*	1941		100		
	SAN JOAQUIN VALLEY					
11	Buena Vista Lake, *Kern*	1934		1,200		1,000
12	Buttonwillow, *Kern*	1926		1,700		985
13	Chowchilla, *Madera*	1935		300		930
14	Trico, *Kern*	1935		7,480		980
15	Semitropic, *Kern*	1932		3,825		980
	COASTAL AREA					
16	Goleta, *Santa Barbara*	1929		200		1,055
17	Total					

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil			
				During 1942		End of 1942			Number of Wells								
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average			Sulphur, Per Cent
60						59	10			10				38	35	37.3	
61						13	19			19				32	19	20.6	
62	With South Mountain			1		4	123		1	122				36	28	35.1	0.69
63						59	48			48				32	16	28.1	0.68
64						11	66			66				24	15	18.5	
65	68,568	3,282				5	93			93				28	20	23.9	1.73
66				2		12	11			11				24	21	22.4	
67				4		1	16			16				24	21	22	
68						1	8			8				34	25	28.7	
69							15			15				23	20	22	
70						3	39			39				28	27	27.5	
71						9	4			4				27	20	23.6	
						37	18			18							
72					3	8	9			9				14	13	13.3	
73						3										22	
74						13										54	
75						13	9			9						13	0.86
76	1,018,131	47,416		85	14	481	1,774		310	1,464							
77							36		1	35				28	16	26.8	1.07
											2,250						
78				4			20		9	11	3,800			54	23	24	0.47
79	61,139	2,771		10		73	346		5	341				32	14	22.5	0.97
80				2			2			2	3,900			22.7	19	20.9	2.42
81	} 55,512	3,729		4	1		132		2	130	2,600	2,100		26	18	25	1.46
82				3		38	129		23	106	2,050	1,650	RP	31	24	28.9	
83	227,648	12,543		4	2	10	295		56	239	{ 1,000 { 3,000	50 } 500 }	RP	35	28	30.4	0.85
84	7,633	206			3	3	35			35				29	15	21.8	2.98
85	320,101	11,080		19	10	79	688		18	670				27	11	23.5	1.30
											1,900	800					2.51
86	99,452	6,342		4	1	32	280		42	238	4,550	4,100		38	14	22.0	0.93
87							3			3				29	23	25.9	
88	881,860	11,628		1	52	58	1,203			1,203				32	12	25.0	1.25
89							93			93				18	13	13.7	1.0
90	106,428	8,179		5	23	29	331		7	324	3,700	(West)		39	13	30.0	0.79
91	50,260	805			10	11	126			126				24	11	21.0	2.7
92				1	1	1	24		7	17				48	33	44.0	
93	87,399	2,435			7	9	345			345				29	14	20.5	1.60
94	127,728	6,778		3	5	7	189		9	180				42	31	33.0	0.48
95	679,778	6,678		1	16	41	574			574				38	28	32.5	0.40
96	104,098	3,955		1	3	8	95		5	90				29	10	23.0	
97	78,953	2,134		10	19	28	635			635				27	13	22.0	1.62
98				1			4		1	3				28	26	27	0.56
99					2	14	163		2	161				30	14	19.0	0.77
											1,500	850					
100	122,869	31,345		37		20	1,095		380	715	2,200	1,850		28	13	21.0	2.5
101	8,036	4,013					23		2	21							
102	3,018,894	114,621		110	155	461	6,866		569	6,297							
103	6,815,882	430,201		569	203	2,481	18,881		1,742	17,139							
Gas Fields																	
1	432	249	4	1							2,488						
2	46,780	11,215	7					7			2,350						
3			1														
4	112,446	76,694	56	11	1			52			1,860	1,650					
5	5,035	953	5	1				4			2,950	2,700					
6	9,816	306	6					3			1,854	1,100					
7			1														
8			2					1			1,450						
9			1														
10			2														
11	4,685	983	8					2			1,260	650					
12	24,264	3,411	27					18									
13			3														
14	13,497	3,805	23	2				19			1,157						
15	6,278	1,838	22					3			1,110	900					
16	Storage		5					4			1,800	Storage					
17	223,233	99,454		15				115									

TABLE 1.—(*Continued*)

	Producing Formation								Deepest Zone Tested to End of 1942	
					Depth, Avg. Ft.					
Line Number	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
60	Modelo	Mio	S		858	1,611	y	A	Eocene	4,300
61	Sespe	Olig	S		400	1,651	y	A & S	Oligocene	3,595
62	Sespe	Olig	S		100	1,927	640	A	Eocene	7,428
63	Meganos	Eoc	S		1,100	1,213	y	A	Eocene	3,934
64	Sespe	Olig	S		315	683	y	MF		
65	Sespe	Olig	S		2,200	3,362	956	A	Eocene	6,702
66	Modelo, Sespe	Mio, Olig	S		500	995	y	A	Eocene	2,956
67	Modelo	Mio	S		2,000	2,411	y	A	Miocene	4,584
68	Repetto, Modelo	Pli, Mio	S		300	2,605	y	MF	Miocene	3,300
69	Modelo	Mio	S		844	1,044	y	ML	Miocene	
70	Vaqueros, Sespe	Mio, Olig	S		700	1,363	y	AF	Miocene	2,500
71	Modelo	Mio	S		500	608	y	AF	Miocene	4,400
72	Monterey	Mio	H		800	1,200	y	A & S	Jurassic schist	2,125
73	Monterey	Mio	H			2,900	y	S	Jurassic schist	4,425
74	Purissima, Monterey	Pli, Mio	S & H		1,379	1,600	y	ML	Miocene	7,982
75	Monterey	Mio	S & H		900	1,500		AF	Franciscan	3,583
76										
77	Pico, Repetto, Puente	Pli, Mio	S		4,635	5,810	250	AF	Miocene	9,054
78	Pico, Repetto, Modelo	Pli, Mio	S		4,795	5,287	170	M	Miocene	9,291
79	Repetto, Puente	Pli, Mio	S		260	3,026	800	AF	Miocene	8,021
80	Repetto	Pli	S		8,900	9,697	55	AU	Miocene	10,044
81	Repetto, Puente	Pli, Mio	S		2,450	3,607	153	AF	Miocene	9,084
82	Repetto	Pli	S	22	2,800	4,471	473	D	Miocene	9,200
83	Repetto, Puente	Pli, Mio	S	28	3,800	5,189	1,460	AF	Miocene	12,720
84	Puente, Franciscan	Mio, Jur	S Fis		6,890	7,316	50	A AF	Franciscan schist	8,009
85	Repetto, Puente	Pli, Mio	S	28	1,900	4,009	1,200	MF	Miocene	9,054
86	Pico, Repetto, Puente, Monterey	Pli, Mio	S		1,073	2,597	975	AF	Miocene	10,598
87	Puente	Mio	S		6,375	5,841	9	MU	Miocene	7,405
88	Pico, Repetto, Puente	Pli, Mio	S	30	2,377	5,264	1,650	AF	Miocene	10,720
89	Repetto, Puente	Pli, Mio	S		475	1,045	9	AF	Miocene	5,074
90	Repetto, Puente	Pli, Mio	S		1,730	4,422	800	A	Miocene	9,334
91	Repetto, Puente, Franciscan	Pli, Mio, Jur	S Fis		3,350	5,371	200	A	Franciscan schist	7,048
92	Pico, Repetto, Puente, Franciscan	Pli, Mio	S	29	3,640	5,592	350	AF	Miocene	9,923
93	Puente	Pli	S		2,900	4,057	510	A	Oligocene, Sespe	10,496
94	Repetto, Puente	Pli, Mio	S	22	4,035	6,150	1,050	AF	Miocene	10,389
95	Repetto, Puente	Pli, Mio	S	29	3,470	5,373	1,360	D	Miocene	11,314
96	Repetto, Puente	Pli, Mio	S		4,314	5,441	350	AF	Miocene	9,054
97	Puente	Mio	S	27	2,637	4,220	120	AF	Franciscan schist	6,957
98	Puente	Mio	S	27	3,300	3,447	191	AF	Miocene	5,309
99	Repetto, Puente	Pli, Mio	S		200	2,109	270	MUF	Miocene	5,040
100	Repetto, Puente	Pli, Mio	S	28	2,320	3,631	420	AF	Franciscan schist	6,814
101						2,314				
102										
103										
	GAS FIELDS									
1	Repetto	Pli	S & H	26	3,800	4,900	170	A	Pliocene	7,708
2	Capay	Eoc	S	29.6	5,178	5,216	29	D	Cretaceous	8,810
3	Cretaceous	Cre	S		3,235	3,265	30	D	Cretaceous	5,334
4	Domingine, Ione	Eoc	S	35	3,800	4,344	148	AF	Cretaceous	7,029
5	Cretaceous	Cre	S	28	2,700	5,855	87	MU	Igneous rock	6,900
6	Cretaceous	Cre	S	28	3,926	4,070	65	D	Cretaceous	9,690
7	Cretaceous	Cre	S		2,345	2,360	10	D	Cretaceous	6,014
8	Cretaceous	Cre	S		3,651	3,682	30	A	Cretaceous	5,185
9	Miocene	Mio	S		1,183	1,215	30		Miocene	1,215
10	Cretaceous	Cre	S		3,840	3,872	30	A	Cretaceous	3,873
11	Etchegoin	Pli	S		4,117	5,219	20	AF	Miocene	11,186
12	Etchegoin	Pli	S		2,500	2,750	18	D	Pliocene	4,946
					2,611	2,923	60			
13	Eocene, Cretaceous	Eoc, Cre	S		7,900	8,125	140	D	Cretaceous	8,377
14	Etchegoin	Pli	S	28	2,420	3,150	13	A	Miocene	11,468
15	Etchegoin	Pli	S	25	2,275	3,215	6	A	Miocene	9,700
16	Vaqueros	Mio	S		4,139	4,533	354	AF	Eocene	6,912
17										

Los Angeles Basin District

Buean Park Field.—By geophysical methods and well correlations, The Texas Company discovered a new type of field in the Los Angeles Basin through the completion of its Spencer No. 1 well at Buean Park, a few miles east of Santa Fe Springs. The discovery well was completed flowing 97 bbl. of 21.2° gravity oil from a depth of 8932 ft., producing from 20 ft. of sand. When placed on the pump the well made over 200 bbl. per day, but had a rapid decline. A second completion showed the same characteristics as the discovery well. Structure is a northwest-plunging nose, overlying the Miocene contact, and production is from overlapping sands equivalent in age to the Bell sand of Santa Fe Springs. This concealed structure is 4000 ft. lower stratigraphically than any other field in the Los Angeles Basin. Like other recent discoveries, this field is a technical triumph but a financial failure.

Aliso Canyon Field.—The Tide Water Associated Oil Co. extended the Aliso Canyon oil field ½ mile west by the completion of its Sesnon No. 1 well, flowing 2400 bbl. a day of 23.1° gravity oil with 1300 M cu. ft. of gas through a 48/64-in. bean. This well is a discovery of a black-oil zone downdip from the gas cap in the Miocene zone.

GAS FIELDS

Because the main gas line from Kettleman Hills to San Francisco was converted into an oil line, northern California is now dependent on dry gas fields for fuel; the main portion of this supply comes from the 25,000-acre Rio Vista gas field, which contains one fourth of the gas reserves (12 trillion cubic feet) of the state.

Many tests for dry gas were drilled in northern California during the year, with one field discovery and two others in the completion stage.

Five miles west of Stockton and 6 miles southeast of the McDonald Island gas field, the Standard Oil Co. discovered a new gas field by the completion of its Woods Community 2-1 well from a depth of 5254 ft. for an estimated daily flow of 10 million cubic feet. Production is from the McDonald Island sand of Eocene age.

DEMAND AND SUPPLY

While domestic demand for gasoline in 1942 declined 8 per cent from 1941, the over-all demand for gasoline decreased less than 1 per cent. With rationing in effect, the civilian use of gasoline is expected to drop further in 1943, but it is more than probable that over-all demand—military and civilian—will be higher than in either 1941 or 1942.

Demand for fuel oil in 1942 is estimated to have been 352,000 bbl. a day against 286,000 bbl. a day in 1941, a 23.1 per cent increase. Fuel-oil supply in 1942 was about 328,000 bbl. a day against 268,000 bbl. a day in 1941, an increase of 22.4 per cent.

TRANSPORTATION

Under normal conditions 23 per cent of the crude oil in the state is transported by tankers from the fields to refineries. Dislocations in this traffic made necessary the conversion of a main gas line into an oil line and the construction of other pipe lines. This has solved the transportation problem to such an extent that most fields now have a full market for all oil produced.

REFINING

Originally designed to produce motor gasoline as its major product, the refining industry has had to revamp its technique and operations to produce not motor fuel but fuel oil for ships and larger amounts of aviation gasoline. Under normal conditions the recovery of gasoline from oil in California would be nearly 40 per cent, but under the impetus of increased demand for fuel oil, and with demand for gasoline down only slightly, gasoline recovery has dropped to 32 per cent. Because of this change in operations, the California motorist is faced not only with a diminishing supply of gasoline but also with the necessity for using a motor fuel definitely inferior in quality to that of 1941.

Advances in Drilling and Production Practices

Restrictions on deep drilling has greatly curtailed the use and development of the modern heavy type of drilling equipment. The major portion of new well developments has been the shallow (1000 ft.) holes to obtain the low-gravity crude needed in the war effort.

Portable masts are drilling an ever increasing percentage of these shallow wells. The tendency in the casing programs has been to set a full combination string and cement through perforations. This has resulted in a great saving in steel as well as money.

With the scarcity of available casing on the market, oil companies are becoming "salvaging experts" in the art of recovering the extra casing from old wells. This practice has provided a great reserve from which many new wells can be adequately supplied.

Drilling with crude oil and oil laden with colloidal and weighting materials has been further tested in both shallow and deep drilling during the year, with apparently very satisfactory results.

The impetus of technical skill and ingenuity has been turned primarily toward the refining part of the industry. The 100-octane gasoline program, together with the synthetic rubber program, has shown the results of this effort.

Conclusion

New drilling will be necessary to increase or hold present production in California, as the normal decline of settled production is more than 15 per cent. The lack of labor is expected to curtail new drilling more than a shortage of material.

It is anticipated that in 1943 wildcat drilling for heavy oil will be encouraged in every possible way to meet the fuel needs of our expanding navy and air force. The necessity for a greater allotment of steel for the industry in California will be recognized, but the shortage will still be acute.

Oil and Gas Development in Illinois in 1942

BY ALFRED H. BELL,* MEMBER A.I.M.E, AND CHARLES W. CARTER*

IN 1942, Illinois produced 106,590,000 bbl. of crude oil, or 7.6 per cent of the entire amount produced in the United States. It ranked fifth among the oil-producing states. The production for 1942 declined 20.5 per cent from the previous year's total of 134,139,000 bbl. The daily average production for 1942 was approximately 292,000 bbl., or 74,000 bbl. less than the 366,000 daily average for 1941. At the beginning of 1942 the daily production was 367,000 bbl. This production declined steadily to 282,000 for June and to 246,000 for December. This steady decline was caused partly by the reduction in drilling resulting from Federal Conservation Order M-68 and partly by the fact that no major pool was found during the year.

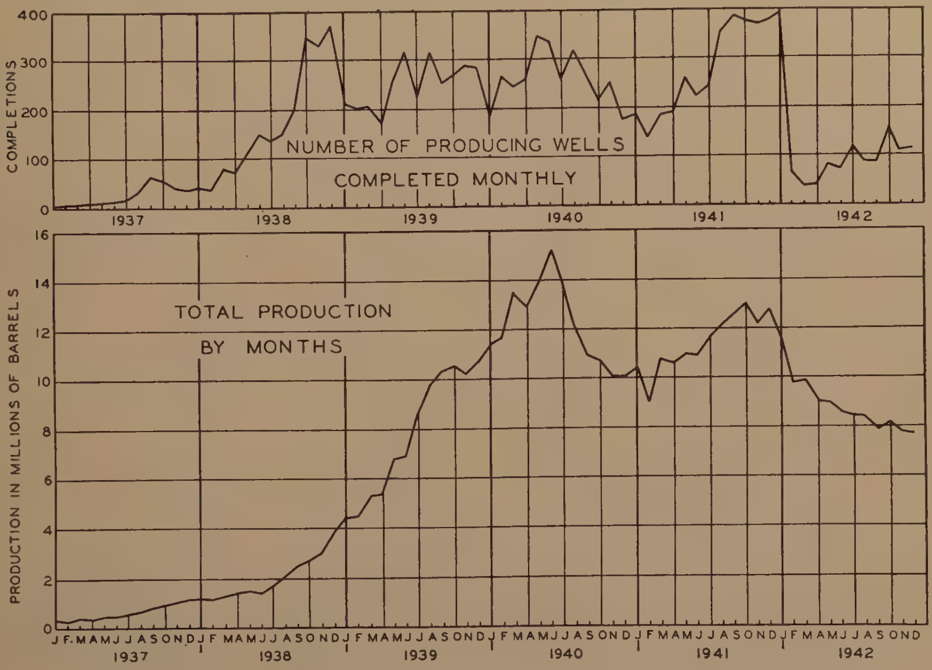

FIG. 1.—MONTHLY OIL PRODUCTION AND WELL COMPLETIONS IN ILLINOIS 1937–1942.

DISCOVERIES

Forty new fields (Fig. 2, Table 2), 48 extensions (Table 3), and 45 additional producing zones in existing fields (Table 4) were discovered in 23 counties in Illinois during 1942. Of the 40 new fields, three

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were abandoned before the end of 1942, 15 were one-well fields, 15 had not more than six wells, and the remaining 7 had from 10 to 32 wells producing at the end of the year. In all, 200 wells were producing in these 37 fields by Jan. 5, 1943. In 1941, for contrast, 43 oil fields were discovered and 869 wells were producing in those fields at the end of that year.

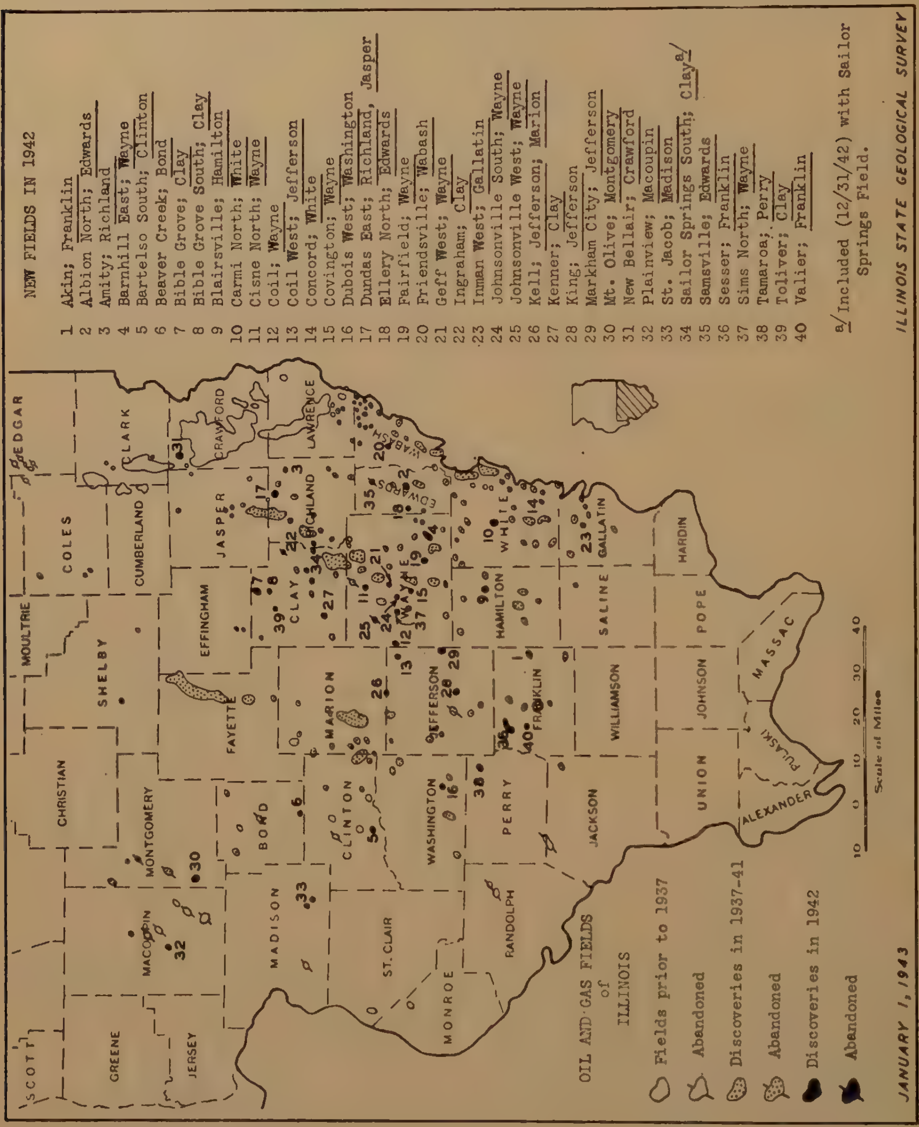

Fig. 2.—Oil and Gas Fields of Illinois showing discoveries of the year 1942.

The average initial productions of the discovery wells of the 40 new fields amounted to 130 bbl. of oil and 23 bbl. of salt water. For the 43 oil discoveries of 1941 the comparable figure is 318 bbl. of oil.

In fields discovered since Jan. 1, 1937, a total of 11,404 wells were producing at the end of 1942 and this compares with 10,496 wells at the end of 1941.

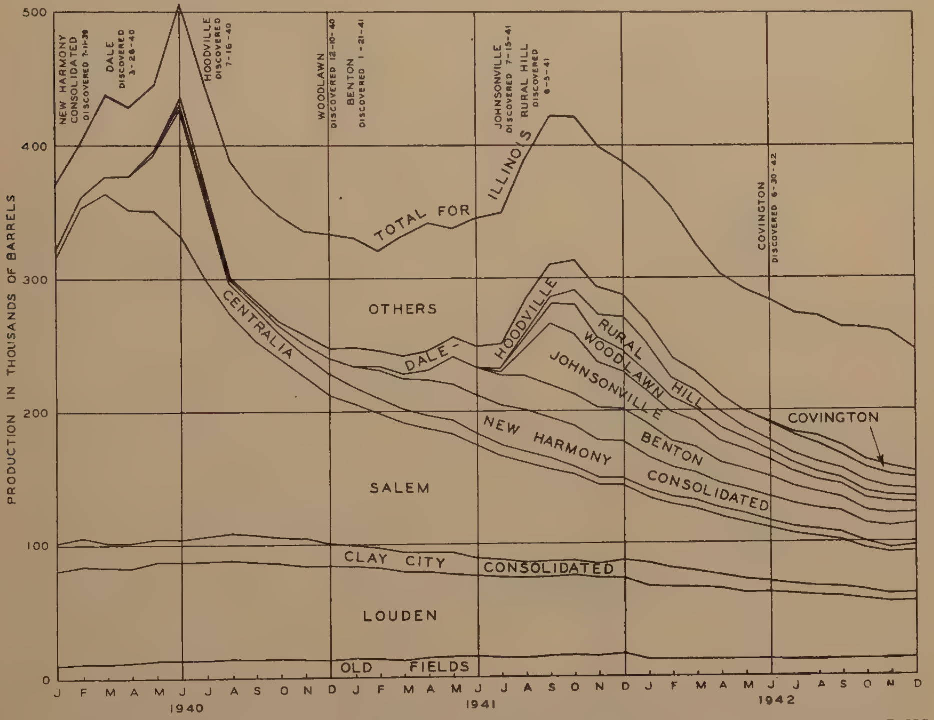

FIG. 3.—DAILY AVERAGE PRODUCTION IN ILLINOIS FOR THE YEARS 1940–1942, DIVIDED ACCORDING TO PRINCIPAL PRODUCING AREAS.

PRODUCTIVE ACREAGE

The area proved for production in the new fields (discovered since 1936) increased from 97,483 acres at the beginning of 1942 to 119,730 acres at the end of the year (Table 1), an increase of 22,247 acres, of which 4540 acres are in fields discovered during the current year and 17,707 in extensions to pools drilled earlier. In 1941 a total of 19,433 acres were added, 9955 by fields discovered during that year and 9478 by extensions to older fields. The 40 new oil fields discovered during 1942 added an average of 114 acres per field whereas the 43 discovered during 1941 added an average of 232 acres per field by the end of that year.

DRILLING

During the past year 2048 wells were completed. Of these, 2016 were oil or gas producers and dry holes and the other 32 were gas-input wells, salt-water-disposal wells, and stratigraphic tests. Of the 2016 wells drilled for oil or gas, 1166 were oil wells, 13 were gas wells and 837 were dry holes. The producers made up 58.5 per cent of the wells drilled. Of the total number drilled 549 are classified as "wildcat," and of these 88 were successful in obtaining production and 8 are either gas wells not connected to a pipe line or "edge wells," which might open new oil fields.

EXPLORATION METHODS

The results of an investigation to ascertain the reason for the locations of the wildcat wells are set forth in Table 6. Of the 549 wildcat wells, the 408 known to have been found by scientific methods were 19 per cent successful. The total

TABLE 1.—*Oil and Gas Production in Illinois*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
1	Warrenton-Borton, *Edgar*	1906	100	0	30,320	120	0	0	22	0	10	4	0	0
2	Westfield, *Clark, Coles*	1904	9,000	75	*x*	*x*	*x*	0	1,628	0	0	16	291	0
3			850	75	*x*	*x*	*x*	0	186	0	0	*y*	*y*	0
4			9,000	0	*x*	*x*	*x*	0	1,449	0	0	*y*	*y*	0
5			220	0	*x*	*x*	*x*	0	13	0	0	*y*	*y*	0
6	Siggins, *Cumberland, Clark*	1906	3,580	105	*x*	*x*	*x*	0	996	0	0	1	802	0
7			3,135	55	*x*	*x*	*x*	0	854	0	0	0	*y*	0
8			435	15	*x*	*x*	*x*	0	90	0	0	1	*y*	0
9			855	105	*x*	*x*	*x*	0	193	0	0	0	*y*	0
10	York, *Cumberland, Clark*	*y*	310	40	*x*	*x*	*x*	0	70	0	0	0	44	0
11	Casey, *Clark*	1906	1,925	55	*x*	*x*	*x*	0	535	0	0	0	488	0
12			190	15	*x*	*x*	*x*	0	41	0	0	0	*y*	0
13			400	0	*x*	*x*	*x*	0	82	0	0	0	*y*	0
14			1,525	15	*x*	*x*	*x*	0	322	0	0	0	*y*	0
15	Martinsville, *Clark*	1922	710	155	*x*	*x*	*x*	0	218	1	0	0	115	0
16			15	20	*x*	*x*	*x*	0	7	0	0	0	*y*	0
17			275	35	*x*	*x*	*x*	0	63	0	0	0	*y*	0
18			710	0	*x*	*x*	*x*	0	23	0	0	0	*y*	0
19			600	0	*x*	*x*	*x*	0	35	1	0	0	*y*	0
20			640	0	*x*	*x*	*x*	0	40	0	0	0	*y*	0
21			10	0	*x*	*x*	*x*	0	2	0	0	0	*y*	0
22	North Johnson, *Clark*	1907	1,320	20	*x*	*x*	*x*	0	485	0	0	0	433	0
23			1,115	0	*x*	*x*	*x*	0	296	0	0	0	*y*	0
24			160	0	*x*	*x*	*x*	0	32	0	0	0	*y*	0
25			820	5	*x*	*x*	*x*	0	177	0	0	0	*y*	0
26			215	0	*x*	*x*	*x*	0	44	0	0	0	*y*	0
27	South Johnson, *Clark*	1907	1,715	65	*x*	*x*	*x*	*x*	535	0	0	0	469	0
28			185	5	*x*	*x*	*x*	*x*	38	0	0	0	*y*	0
29			295	0	*x*	*x*	*x*	*x*	59	0	0	0	*y*	0
30			1,675	35	*x*	*x*	*x*	*x*	402	0	0	0	*y*	0
31			845	5	*x*	*x*	*x*	*x*	170	0	0	0	*y*	0
32	Bellair, *Crawford, Jasper*	1907	1,300	5	*x*	*x*	*x*	*x*	486	0	13	20	362	0
33			1,165	0	*x*	*x*	*x*	*x*	310	0	*y*	*y*	*y*	0
34			315	0	*x*	*x*	*x*	*x*	65	0	*y*	*y*	*y*	0
35			910	0	*x*	*x*	*x*	*x*	182	0	*y*	*y*	*y*	0
36	Clark County Division[1]		19,960	520	53,491,000	374,000	*x*	*x*	4,953	1	13	37	3,004	0
37	Main,[2] *Crawford*	1906	35,135	515	*x*	*x*	*x*	*x*	7,324	0	58	53	4,821	*y*
38			340	0	*x*	*x*	*x*	*x*	68	0	0	0	*y*	*y*
39			33,795	510	*x*	*x*	*x*	*x*	7,143	0	58	53	*y*	*y*
40			1,000	0	*x*	*x*	*x*	*x*	108	0	0	0	*y*	*y*
41			10	0	*x*	*x*	*x*	*x*	1	0	0	0	1	0
42	New Hebron, *Crawford*	1909	1,350	210	*x*	*x*	*x*	*x*	297	0	0	0	146	0
43	Chapman, *Crawford*	1914	1,045	515	*x*	*x*	*x*	*x*	193	0	0	0	60	0
44	Parker, *Crawford*	1907	1,310	30	*x*	*x*	*x*	*x*	256	0	1	0	219	0
45	Allison-Weger, *Crawford*	*y*	1,075	20	*x*	*x*	*x*	*x*	148	1	0	0	66	0
46	Flat Rock,[3] *Crawford*	*y*	1,375	545	*x*	*x*	*x*	*x*	289	0	6	0	130	0
47	Birds, *Crawford, Lawrence*	*y*	4,370	115	*x*	*x*	*x*	*x*	684	0	4	2	424	0
48	Crawford County Division[6]		45,665	1,945	148,653,000	1,347,000	*x*	*x*	9,191	1	69	55	5,866	0
49	Lawrence, *Lawrence, Crawford*	1906	24,150	1,550	*x*	*x*	*x*	*x*	4,415	2	42	23	3,155	0
50			50	0	*x*	*x*	*x*	*x*	5	0	*y*	*y*	5	0

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Total of lines 2, 6, 10, 11, 15, 22, 27, 32.

[2] Includes Kibbie, Oblong, Robinson and Hardinsville.

[3] Includes Swearingen gas.

[6] Total of lines 37, 42, 43, 44, 45, 46, 47.

TABLE 1.—(*Continued*)

	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.			Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells											Depth, Avg. Ft.					
Line Number	Flowing	Artificial Lift	Initial	Avg. at End of 1942	Repressuring Operation[d]	Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	0	0	*x*	*x*		*x*	*x*	Unnamed	Pen	S	Por	159	215	*x*	ML	Pen	715
2	0	291	293±	*x*		34.0	*x*	See below							D	St. Peter	3,009
3	0	*y*	*x*	*x*		30.0	*x*	Shallow gas	Pen	S	Por	281	376	36	D		
4	0	*y*	*x*	*x*		33.5	*x*	Westfield	MisL	L	Cav	334	446	*x*	D		
5	0	*y*	*x*	*x*		38.2	0.18	"Trenton"	Ord	L	Por	2,265	2,568	*x*	D		
6	0	802	*x*	*x*	RP	33.0	*x*	See below							D	Dev	2,010
7	0	*y*	*x*	*x*		34.0	*x*	First Siggins	Pen	S	Por	367	465	*x*	D		
8	0	*y*	*x*	*x*		(33.6)	*x*	2nd and 3rd Siggins	Pen	S	Por	478	562	*x*	D		
9	0	*y*	*x*	*x*		(25.7)	*x*	Lower Siggins	Pen	S	Por	556	590	*x*	D		
10	0	44	*x*	*x*		(30.3)	*x*	York	Pen	S	Por	588	680	*x*	AM	Pen	960
11	0	488	*x*	*x*	RP	29.2	*x*	See below							AM	MisL	808
12	0	*y*	*x*	*x*		(31.9)	*x*	Upper gas	Pen	S	Por	263	358	*x*	AM		
13	0	*y*	*x*	*x*		(30.1)	*x*	Lower gas	Pen	S	Por	309	426	*x*	AM		
14	0	*y*	*x*	*x*		(33.6)	*x*	Casey	Pen	S	Por	444	505	*x*	AM		
15	0	115	*x*	*x*		36.8	*x*	See below							D	St. Peter	3,411
16	0	*y*	*x*	*x*		*y*	*x*	Shallow	Pen	S	Por	255	411	*x*	D		
17	0	*y*	*x*	*x*		*y*	*x*	Casey	Pen	S	Por	499	511	*x*	D		
18	0	*y*	*x*	*x*		*y*	*x*	Martinsville	MisL	L	Por	477	506	*x*	D		
19	0	*y*	*x*	*x*		(38.9)	*x*	Carper	MisL	S	Por	1,340	1,418	*x*	D		
20	0	*y*	*x*	*x*		*y*	*x*	"Niagaran"	Dev	L	Por	1,553	1,596	*x*	D		
21	0	*y*	*x*	*x*		(39.6)	*x*	"Trenton"	Ord	L	Por	2,708	2,830	*x*	D		
22	0	433	*x*	*x*		31.0	*x*	See below							AM	Mis	965
23	0	*y*	*x*	*x*		*y*	*x*	Claypool	Pen	S	Por	416	486	*x*	AM		
24	0	*y*	*x*	*x*		*y*	*x*	Shallow	Pen	S	Por	314	451	*x*	AM		
25	0	*y*	*x*	*x*		*y*	*x*	Casey	Pen	S	Por	465	508	*x*	AM		
26	0	*y*	*x*	*x*		*y*	*x*	Upper Partlow	Pen	S	Por	534	554	*x*	AM		
27	0	469	*x*	*x*		32.2	*x*	See below							AM	Dev	2,030
28	0	*y*	*x*	*x*		*y*	*x*	Claypool	Pen	S	Por	392	549	*x*	AM		
29	0	*y*	*x*	*x*		*y*	*x*	Casey	Pen	S	Por	453	518	*x*	AM		
30	0	*y*	*x*	*x*		*y*	*x*	Upper Partlow	Pen	S	Por	489	570	*x*	AM		
31	0	*y*	*x*	*x*		28.5	*x*	Lower Partlow	Pen	S	Por	598	618	*x*	AM		
32	0	375	*x*	*x*	RP	33.7	*x*	See below							AM	MisL	1,471
33	0	*y*	*x*	*x*		(32.4)	*x*	"500 Ft."	Pen	S	Por	561	725	*x*	AM		
34	0	*y*	*x*	*x*		*y*	*x*	"800 Ft."	Pen	S	Por	817	907	*x*	AM		
35	0	*y*	*x*	*x*		(37.0)	*x*	"900 Ft."	MisU	S	Por	886	920	*x*	AM		
36	0	3,017	*x*	*x*		33.0										St. Peter	4,654
37	0	4,821	425±	*y*	RP	33.0	*x*	See below									
38	0	*y*	*x*	*x*		*y*	*x*	Shallow	Pen	S	Por	508	822	*x*	ML		
39	0	*y*	*x*	*x*		32.8	*x*	Robinson	Pen	S	Por	900	960	25±	ML		
40	0	*y*	*x*	*x*		*y*	*x*	Oblong	Mis	SL	Por	1,337	1,416	*x*	A, ML		
41	0	1	*x*	*x*		*y*	*x*	Devonian	Dev	L	Por	2,794	2,805	11	ML		
42	0	146	*x*	*x*	RP	30.1	*x*	Robinson	Pen	S	Por	940	975	*x*	ML	Mis	2,056
43	0	60	*x*	*x*		*y*	*x*	Robinson	Pen	S	Por	995	1,015	*x*	ML	Mis	2,279
44	0	219	*x*	*x*		29.5	*x*	Robinson	Pen	S	Por	1,000	1,025	*x*	ML	Pen	1,127
45	0	66	*x*	*x*		22.5	*x*	Robinson	Pen	S	Por	912	930	*x*	ML	Pen	1,041
46	0	130	*x*	*x*	RP	31.8	*x*	Robinson (Flat Rock)	Pen	S	Por	935	945	*x*	ML	Dev	3,110
47	0	424	*x*	*x*	RP	31.8	*x*	Robinson	Pen	S	Por	930	950	*x*	ML	MisL	1,731
48	0	5,866	425±	*x*		32.3	*x*									St. Peter	4,654
49	0	3,155	650±	*x*	RP	32.9	*x*	See below							A	St. Peter	5,190
50	0	5	*x*	*x*		*y*	*x*	Pennsylvanian	Pen	S	Por	290	320	*x*	A		

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[4] Pressures in Southeastern Illinois oil fields are estimated bottom hole pressures reported in previous Survey publications.

[5] All gravities given prior to 1936 (except those in parentheses) were from data for the year 1925 furnished by the Illinois Pipe Line Co. Gravities in parentheses are for particular samples (see Illinois State Geol. Survey *Bull.* 54, Table 3). The values have been converted from Baume to A.P.I. gravities.

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres: Oil	Area Proved, Acres: Gas[b]	Total Oil Production, Bbl.: To End of 1942	Total Oil Production, Bbl.: During 1942	Total Gas Production, Millions Cu. Ft.: To End of 1942	Total Gas Production, Millions Cu. Ft.: During 1942	Number of Oil and/or Gas Wells: Completed to End of 1942	During 1942: Completed	During 1942: Abandoned	End of 1942: Temporarily Shut Down	End of 1942: Producing Oil[c]	End of 1942: Producing Gas[c]
51			5,015	35	*x*	*x*	*x*	*x*	1,233	0	*y*	*y*	*y*	0
52			2,240	0	*x*	*x*	*x*	*x*	476	0	*y*	*y*	*y*	0
53			345	1,095	*x*	*x*	*x*	*x*	243	0	*y*	*y*	*y*	0
54			15,960	220	*x*	*x*	*x*	*x*	3,017	0	*y*	*y*	*y*	0
55			4,020	200	*x*	*x*	*x*	*x*	693	2	*y*	*y*	*y*	0
56			6,950	0	*x*	*x*	*x*	*x*	959	0	*y*	*y*	*y*	0
57	St. Francisville, *Lawrence*		420	0	*x*	*x*	*x*	*x*	55	0	0	0	30	0
58	Lawrence County Division[7]		24,570	1,550	229,523,000	1,733,000	*x*	*x*	4,470	2	42	23	3,185	0
59	Allendale, *Wabash*	1912	2,100	0	5,530,000	424,000	*x*	*x*	503	30	1	3	278	0
60			*y*	0	*x*	*x*	*x*	*x*	448	18	0	0	227	0
61			*y*	0	*x*	*x*	*x*	*x*	3	0	1	2	0	0
62			*y*	0	*x*	*x*	*x*	*x*	5	2	0	0	5	0
63			*y*	0	*x*	*x*	*x*	*x*	6	0	0	0	6	0
64			*y*	0	*x*	*x*	*x*	*x*	32	9	0	1	32	0
65			*y*	0	*x*	*x*	*x*	*x*	8	1	0	0	8	0
66	Total Southeastern Fields[8]		92,275	3,970	437,227,320	3,878,120	*x*	*x*	19,139	34	135	122	12,333	0
67	Ayers gas, *Bond*	1922	0	325	0	0	221.2	13.4	20	1	0	0	0	8
68	Greenville gas, *Bond*	1910[9]	0	160	0	0	990.0	0	4	0	0	0	0	0
69	Bartelso, *Clinton*	1936	580	0	1,202,000	185,000	0	0	72	0	0	4	66	0
70			320	0	782,000	105,000	0	0	47	0	0	1	44	0
71			230	0	420,000	80,000	0	0	25	0	0	3	22	0
72	Carlyle, *Clinton*	1911	915	0	3,451,000	23,000	0	0	165	0	45	10	88	0
73	Frogtown, *Clinton*	1918[10]	300	0	*x*	0	0	0	12	0	0	0	0	0
74	Ava-Campbell Hill, *Jackson*	1917[11]	70	370	*x*	0	*x*	0	35	0	0	0	0	0
75	Colmar-Plymouth, *McDonough, Hancock*	1914	2,450	0	2,894,000	107,000	0	0	486	1	0	71	219	0
76	Carlinville, *Macoupin*	1909[12]	30	50	*x*	1,000	*x*	0	8	0	0	4	0	0
77	Gillespie-Benld gas, *Macoupin*	1923[13]	0	80	0	0	135.8	0	4	0	0	0	0	0
78	Gillespie-Wyen, *Macoupin*	1915	40	0	*x*	1,000	0	0	22	0	0	4	8	0
79	Spanish Needle Creek, *Macoupin*	1915[14]	0	80	0	0	14.4	0	7	0	0	0	0	0
80	Staunton gas, *Macoupin*	1916[15]	0	400	0	0	1,050.0	0	18	0	0	0	0	0
81	Collinsville, *Madison*	1909[16]	40	0	850	0	0	0	6	0	0	0	0	0
82	Brown-Langewisch Kuester-Junction City, *Marion*	1910	175	0	*x*	*x*	0	0	13	3	0	0	12	0
83			60	0	*x*	*x*	0	0	7	1	0	0	6	0
84			115	0	*x*	*x*	0	0	6	2	0	0	6	0
85	Sandoval, *Marion*	1909	770	0	4,894,000	263,000	0	0	150	0	3	0	25	0
86			770	0	2,695,000	5,000	0	0	123	0	3	0	8	0
87			380	0	2,199,000	258,000	0	0	27	0	0	0	17	0
88	Wamac, *Marion, Clinton, Washington*	1921	250	0	456,000	17,000	0	0	106	2	0	5	27	0
89	Litchfield, *Montgomery*	1879[17]	100	0	22,300	300	0	0	18	0	0	1	0	0
90	Waterloo, *Monroe*	1920[18]	230	0	220,000	6,000	0	0	41	0	1	12	0	0
91	Jacksonville gas, *Morgan*	1910[19]	30	1,290	2,100	0	*x*	0	53	0	0	0	0	0
92	Pittsfield (Pike County) gas	1886[20]	0	8,960	0	0	*x*	0	68	0	0	0	0	0
93	Sparta, *Randolph*	1888[21]	65	100	*x*	0	*x*	0	20	0	0	0	0	0

[7] Total of lines 49 and 57.
[8] Total of lines 1, 36, 48, 58, 59.
[9] Abandoned 1923.
[10] Abandoned 1933.
[11] Abandoned 1934.
[12] Abandoned 1925, revived 1942.
[13] Abandoned 1935.
[14] Abandoned 1934.
[15] Abandoned 1919.
[16] Abandoned 1921.
[17] Abandoned 1904, revived 1942.
[18] Abandoned 1930, revived 1939.
[19] Abandoned 1937.
[20] Gas not used until 1905; abandoned 1930.
[21] Abandoned 1900.

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells											Depth, Avg. Ft.					
	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
51	0	*y*	*x*	*x*		*y*	*x*	Bridgeport	Pen	S	Por	800	1,000	40	A		
52	0	*y*	*x*	*x*		*y*	*x*	Buchanan	Pen	S	Por	1,250	1,265	15	A		
53	0	*y*	*x*	*x*		*y*	*x*	"Gas"	MisU	S	Por	1,330	1,345	15	A		
54	0	*y*	600±	*x*		*y*	*x*	Kirkwood	MisU	S	Por	1,400	1,430	30	A		
55	0	*y*	650±	*x*		*y*	*x*	Tracey	MisU	S	Por	1,560	1,580	20	A		
56	0	*y*	*x*	*x*		*y*	*x*	McClosky	MisL	L	Por	1,700	1,710	10	A		
57	0	30	600	*x*		37.3	*x*	Bethel	MisU	S	Por	1,843	1,865	22	ML	Mis	1,900
58	0	3,185	*x*	*x*												St. Peter	5,190
59	0	278			RP										AM	MisL	2,367
60	0	227	*x*	*x*		35.1	*x*	Biehl	Pen	S	Por	1,425	1,460	20			
61	0	0	*x*	*x*		*y*	*x*	Waltersburg	MisU	S	Por	1,540	1,560	15			
62	0	5	*x*	*x*		*y*	*x*	Tar Springs	MisU	S	Por	1,620	1,640	20			
63	0	6	*x*	*x*		*y*	*x*	Cypress	MisU	S	Por	1,920	1,930	10			
64	0	32	*x*	*x*		*y*	*x*	Bethel	MisU	S	Por	2,010	2,020	9			
65	0	8	900	*x*		*y*	*x*	McClosky	MisL	L	Por	2,280	2,290	8			
66	0	12,333															
67	0	8	335	*y*				Bethel	MisU	S	Por	940	945	5	A	Dev	2,181
68	0	0	*x*					Lindley (1st., 2d)	MisU	S	Por	927	993	*x*	A	Dev	2,290
69	0	66													D	St. Peter	4,213
70	0	44	*x*	*x*		36.2	0.20	Carlyle	MisU	S	Por	984	1,008	24	D		
71	0	22	*x*	*x*		41.5	0.27	Devonian	Dev	L	Por	2,429	2,447	9	D		
72	0	88	*x*	*x*		35.2	0.26	Carlyle	MisU	S	Por	1,035	1,055	20	A	St. Peter	4,120
73	0	0	*x*	*x*		31.9	*x*	Carlyle	MisU	S	Por	950	957	7	D	Cypress	962
74	0	0	*x*	*x*		*x*	*x*	Cypress	MisU	S	Por	780	798	18	A	Dev	2,530
75	0	219	*x*	*x*	RP	37.6	0.38	Hoing	Dev	S	Por	447	468	21	A	"Trenton"	805
76	0	0	135			27.7	*x*	Unnamed	Pen	S	Por	380	398	*x*	A	Pen	410
77	0	0	155					Unnamed	Pen	S	Por	542	555	*x*	A	Pen	575
78	0	8	*x*	*x*		30.0	*x*	Unnamed	Pen	S	Por	650	670	*x*	T	"Trenton"	2,560
79	0	0	*x*					Unnamed	Pen	S	Por	305	405	*x*	D	Pen	495
80	0	0	145					Unnamed	Pen	S	Por	461	491	*x*	A	"Trenton"	2,371
81	0	0	*x*			*x*	*x*	Devonian-Silurian	Dev-Sil	L	Por	1,305	1,400	20	ML	Sil	1,500
82	0	12															
83	0	6	*x*	*x*		32.0	*x*	Dykstra, Wilson	Pen	S	Por	610	630	20	D	MisL	2,001
84	0	6	*x*	*x*		32.0	*x*	Cypress	MisU	S	Por	1,658	1,673	15	D	Dev	3,344
85	0	25													D	St. Peter	5,023
86	0	8	*x*	*x*		34.5	*x*	Benoist	MisU	S	Por	1,540	1,560	20±	D		
87	0	17	*x*	*x*		38.0	0.38	Devonian	Dev	L	Por	2,924	2,969	9	D		
88	0	27	*x*	*x*		30.2	*x*	Petro	Pen	S	Por	720	760	20	D	MisL	1,760
89	0	0	*x*			23.0	0.42	Unnamed	Pen	S	Por	664	674	*x*	D	Pen	681
90	0	0	*x*	*x*		30.2	0.79	"Trenton"	Ord	L	Por	410	460	50	A	"Trenton"	845
91	0	0	*x*	*x*		*x*	*x*	Gas	Pen, MisL	S, SL	Por	330	335	5	ML	"Trenton"	1,390
92	0	0	*x*	*x*				"Niagaran"	Sil	L	Por	265	275	10	A	St. Peter	893
93	0	0	*x*	*x*		*x*	*x*	Cypress	MisU	S	Por	850	857	7	D	MisU	985

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[d]
94	Dupo, *St. Clair*	1928	670	0	1,851,000	272,000	*x*	0	295	5	1	2	93	0
95	Total for fields discovered prior to Jan. 1, 1937[22]		99,020	15,835	452,286,420	4,753,420	2,401	13.4	20,762	46	185	230	12,871	8
96	Beaver Creek, *Bond*	1942	30	0	3,000	3,000	0	0	2	2	0	0	2	0
97	Sorento, *Bond*	1938	30	0	4,000	0	0	0	3	0	0	1	0	0
98	Woburn, *Bond*	1940	210	0	343,000	86,000	0	0	28	1	0	0	28	0
99	Bible Grove, *Clay*	1942	820	0	290,000	290,000	0	0	33	33	0	0	32	0
100			*x*	0	*x*	*x*	0	0	26	26	0	1	25	0
101			*x*	0	*x*	*x*	0	0	7	7	0	0	7	0
102	Bible Grove South, *Clay*	1942	10	0	7,000	7,000	0	0	1	1	0	0	1	0
103	Clay City West, *Clay*	1941	320	0	849,000	800,000	0	0	14	12	0	0	14	0
104	Flora, *Clay*	1938	320	0	460,000	74,000	0	0	22	1	0	0	19	0
105			10	0	*x*	*x*	0	0	1	0	0	0	1	0
106			*y*	0	*x*	*x*	0	0	3	0	0	0	3	0
107			10	0	*x*	*x*	0	0	1	0	0	0	1	0
108			*y*	0	*x*	*x*	0	0	17	1	0	0	14	0
109	Ingraham, *Clay*	1942[23]	10	0	300	300	0	0	1	1	1	0	0	0
110	Iola, *Clay*	1939[24]	100	0	13,000	2,000	0	0	8	3	0	0	6	0
111			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
112			*x*	0	*x*	*x*	0	0	6	1	0	0	4	0
113									1	1	0	0	1	0
114	Kenner, *Clay*	1942	10	0	600	600	0	0	1	1	0	0	1	0
115	Sailor Springs Consolidated, *Clay*	1941	540	0	521,000	356,000	0	0	42	17	2	0	40	0
116			*x*	0	*x*	*x*	0	0	22	2	1	0	21	0
117			*x*	0	*x*	*x*	0	0	15	11	0	0	15	0
118			*x*	0	*x*	*x*	0	0	5	4	1	0	4	0
119	Toliver, *Clay*	1942	10	0	2,000	2,000	0	0	1	1	0	0	1	0
120	Xenia, *Clay*	1941	10	0	7,000	5,500	0	0	1	1	0	0	1	0
121	Clay City Consolidated, *Clay, Wayne*	1937	13,420	0	27,643,000	2,752,000	0	0	718	18	10	5	683	0
122			*x*	0	*x*	*x*	0	0	28	5	2	0	26	0
123			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
124			*x*	0	*x*	*x*	0	0	12	3	1	0	11	0
125			*x*	0	*x*	*x*	0	0	4	1	0	0	4	0
126			*x*	0	*x*	*x*	0	0	661	5	7	5	629	0
127									12	4	0	0	12	0
128	Bartelso South, *Clinton*	1942	10	0	800	800	0	0	1	1	0	0	1	0
129	Boulder, *Clinton*	1941	210	10	375,000	375,000	*x*	*x*	26	25	0	0	25	1
130			*x*	*x*	*x*	*x*	0	0	24	24	0	0	24	0
131			*x*	*x*	*x*	*x*	*x*	*x*	2	1	0	0	1	1
132	Centralia West, *Clinton*	1940	90	0	56,000	43,000	0	0	9	3	0	0	9	0
133	Hoffman, *Clinton*	1939	300	0	363,000	97,000	0	0	44	0	0	0	44	0
134			*x*	0	*x*	*x*	0	0	10	0	0	0	10	0
135			*x*	0	*x*	*x*	0	0	34	0	0	0	34	0
136	Posey, *Clinton*	1941	20	0	3,500	1,500	0	0	2	0	0	0	2	0
137	Centralia, *Clinton, Marion*	1937	2,850	0	22,360,000	2,262,000	0	0	906	0	53	9	739	0
138			*x*	0	*x*	*x*	0	0	23	0	2	0	21	0
139			*x*	0	*x*	*x*	0	0	562	0	11	3	517	0
140			*x*	0	11,888,000	1,158,000	0	0	319	0	40	5	200	0
141			*x*	0	24,000	4,000	0	0	2	0	0	1	1	0
142	Cooks Mills, *Coles*	1941	20	0	4,000	3,000	0	0	2	1	0	1	1	0
143	Mattoon	1939[25]	20	0	23,000	6,000	0	0	2	0	0	0	1	0
144			10	0	*x*	*x*	0	0	1	0	0	0	0	0

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[22] Total of lines 66 to 94 inclusive. Cumulative oil production total based on the U. S. Bureau of Mines monthly report.

[23] Abandoned 1942.

[24] Abandoned 1940: revived 1941.

[25] Abandoned 1939: revived 1940.

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942: Number of Wells: Flowing	Oil-production Methods, End of 1942: Number of Wells: Artificial Lift	Reservoir Pressure,[4] Lb. per Sq. In.: Initial	Reservoir Pressure,[4] Lb. per Sq. In.: Avg. at End of 1942	Repressuring Operation[d]	Character of Oil: Gravity A.P.I. at 60°F., Weighted Average[5]	Character of Oil: Sulphur, Per Cent	Producing Formation: Name	Producing Formation: Age[e]	Producing Formation: Character[f]	Producing Formation: Porosity[g]	Producing Formation: Depth, Avg. Ft.: Top Prod. Zone	Producing Formation: Depth, Avg. Ft.: Bottoms Prod. Wells	Producing Formation: Net Thickness, Avg. Ft.	Producing Formation: Structure[h]	Deepest Zone Tested to End of 1942: Name	Deepest Zone Tested to End of 1942: Depth of Hole, Ft.
94	0	93	x	x		32.7	0.70	"Trenton"	Ord	L	Por	561	601	50	A	"Trenton"	819
95	0	12,871															
96	0	2	x	x		34.2	0.25	Bethel	MisU	S	Por	1,116	1,123	7	A	Dev	2,526
97	0	0	x	x		35.4	x	Devonian	Dev	L	Por	1,830	1,893	5	D	Dev	1,900
98	0	28	x	x		36.4	0.20	Bethel	MisU	S	Por	1,008	1,024	11	A	Dev	2,454
99	0	32													D	MisL	2,971
100	0	25	x	x		38.0	0.13	Weiler	MisU	S	Por	2,490	2,504	14			
101	0	7	x	x		36.2	x	McClosky	MisL	L	Por	2,810	2,817	7			
102	0	1	x	x		x	x	Aux Vases	MisU	S	Por	2,733	2,738	5	A	MisL	2,929
103	0	14	x	x		39.0	0.17	McClosky	MisL	L	Por	3,050	3,080	15	A	MisL	3,080
104	0	19													D	MisL	3,100
105	0	1	x	x		x	x	Tar Springs	MisU	S	Por	2,320	2,332	12			
106	0	3	x	x		x	x	Cypress	MisU	S	Por	2,595	2,614	5			
107	0	1	x	x		37.4	x	Bethel	MisU	S	Por	2,788	2,800	12			
108	0	14	x	x		37.2	0.24	McClosky	MisL	L	Por	2,965	2,978	6			
109	0	0	x	x		x	x	McClosky	MisL	L	Por	3,098	3,139	7	A	MisL	3,139
110	0	6													D	MisU	2,383
111	0	1	x	x		x	x	Bethel	MisU	S	Por	2,292	2,306	14			
112	0	4	x	x		35.4	0.25	Aux Vases	MisU	S	Por	2,335	2,351	11			
113	0	1						[27]									
114	0	1	x	x		x	x	Bethel	MisU	S	Por	2,661	2,672	7	A	MisL	2,955
115	0	40													D	MisL	3,083
116	0	21	x	x		39.5	0.17	Tar Springs	MisU	S	Por	2,340	2,360	15			
117	0	15	x	1,000±		38.5	0.28	Cypress	MisU	S	Por	2,590	2,610	10			
118	0	4	x	x		36.4	x	McClosky	MisL	L	Por	3,009	3,047	5			
119	0	1	x	x		37.1	x	McClosky	MisL	L	Por	2,790	2,800	9	A	MisL	2,887
120	0	1	x	x		35.2	x	Aux Vases	MisU	S	Por	2,785	2,806	12	D	MisL	2,991
121	0	683			PM										A	Dev	4,840
122	0	26	x	x		37.9	x	Cypress	MisU	S	Por	2,670	2,680	10			
123	0	1	x	x		38.0	x	Bethel	MisU	S	Por	2,880	2,885	5			
124	0	11	x	x		38.0	x	Aux Vases	MisU	S	Por	2,910	2,935	15			
125	0	4	x	x		38.0	x	Rosiclare	MisL	S	Por	2,970	2,974	4			
126	0	629	x	x		38.5	x	McClosky	MisL	L	Por	2,980	2,990	10			
127	0	12						[27]									
128	0	1	x	x		39.0	x	Devonian	Dev	L	Por	2,463	2,478	15	D	Dev	2,478
129	0	25													D	Dev	2,670
130	0	24	x	x		36.0	x	Bethel	MisU	S	Por	1,193	1,203	10			
131	0	1	x	x		x	x	Devonian	Dev	L	Por	2,618	2,668	y			
132	0	9	x	x		37.8	0.17	Bethel	MisU	S	Por	1,408	1,415	7	D	MisU	1,450
133	0	44													D	Dev	2,914
134	0	10	x	x		x	x	Cypress	MisU	S	Por	1,185	1,201	9			
135	0	34	x	x		32.2	0.21	Bethel	MisU	S	Por	1,319	1,326	7			
136	0	2	x	x		36.1	0.17	Cypress	MissU	S	Por	1,105	1,110	5	D	MisU	1,144
137	0	739			PM										A	"Trenton"	4,068
138	0	21	x	x		36.4	0.20	Cypress	MisU	S	Por	1,200	1,215	15			
139	0	517	x	25±		37.7	0.17	Bethel	MisU	S	Por	1,355	1,375	20			
140	0	200	x	275		37.4	0.38	Devonian	Dev	L	Por	2,860	2,874	14			
141	0	1	x	x		43.2	0.28	Trenton	Ord	L	Por	4,020	4,120	40			
142	0	1	x	x		36.4	0.40	Aux Vases	MisU	S	Por	1,824	1,834	10	A	MisU	1,873
143	0	1													A	Shakopee	4,914
144	0	0	x	x		44.1	0.16	Cypress	MisU	S	Por	1,835	1,919	25			

[27] Wells producing from more than one sand, see Table 9.

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
145			10	0	23,000	6,000	0	0	1	0	0	0	1	0
146	New Bellair, *Crawford*	1942	20	0	5,000	5,000	0	0	2	2	0	1	1	0
147	Albion, *Edwards*	1940	830	0	2,339,000	498,000	0	0	81	2	1	0	80	0
148			*x*	0	*x*	*x*	0	0	3	0	0	0	3	0
149			*x*	0	*x*	*x*	0	0	10	0	0	0	10	0
150			*x*	0	*x*	*x*	0	0						
151			*x*	0	*x*	*x*	0	0	2	2	0	0	2	0
152			*x*	0	*x*	*x*	0	0	61	0	1	0	60	0
153									5	0	0	0	5	0
154	Albion North, *Edwards*	1942	10	0	3,000	3,000	0	0	1	1	0	0	1	0
155	Bone Gap, *Edwards*	1941	340	0	293,000	227,000	0	0	18	14	0	0	18	0
156	Cowling, *Edwards*	1939	100	0	277,000	32,000	0	0	13	0	1	0	12	0
157	Ellery North, *Edwards*	1942	10	0	1,000	1,000	0	0	1	1	0	0	1	0
158	Samsville, *Edwards*	1942[26]	10	0	*x*	*x*	0	0	1	1	1	0	0	0
159	Ellery, *Edwards, Wayne*	1941	20	0	22,000	9,000	0	0	2	0	0	0	2	0
160	Grayville, *Edwards, White*	1939	80	0	142,000	18,000	0	0	8	0	1	0	3	0
161	Mason, *Effingham*	1940	100	0	143,000	35,000	0	0	9	1	0	0	9	0
162	Mason South, *Effingham*	1941	300	0	180,000	171,000	0	0	22	14	0	0	22	0
163			*x*	0	*x*	*x*	0	0	15	8	0	0	15	
164			*x*	0	*x*	*x*	0	0						
165			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
166									6	6	0	0	6	0
167	Louden, *Effingham, Fayette*	1937	20,020	0	87,685,000	17,966,000	0	0	1,970	36	4	0	1,946	0
168			20,020	0	*x*	*x*	0	0	942	14	0	0	942	0
169			11,000	0	*x*	*x*	0	0	323	1	2	0	321	0
170			7,000	0	*x*	*x*	0	0	419	1	2	0	417	0
171			2,570	0	3,471,000	2,441,000	0	0	75	16	0	0	75	0
172									191	4	0	0	191	0
173	St. James, *Fayette*	1938	1,900	0	5,655,000	1,477,000	0	0	190	2	1	0	183	0
174	St. Paul, *Fayette*	1941	170	0	85,000	81,000	0	0	13	11	0	0	13	0
175	Akin, *Franklin*	1942	50	0	36,000	36,000	0	0	3	3	0	0	3	0
176	Benton, *Franklin*	1941	2,020	0	12,376,000	5,386,000	0	0	231	9	2	0	229	0
177	Benton North, *Franklin*	1941	90	0	129,000	96,000	0	0	11	5	0	0	11	0
178			*x*	0	*x*	*x*	0	0	3	3	0	0	3	0
179			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
180			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
181			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
182			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
183			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
184	Sesser, *Franklin*	1942	30	0	18,000	*x*	0	0	3	3	0	0	3	0
185	Thompsonville, *Franklin*	1940	220	0	222,000	34,000	0	0	19	0	4	0	15	0
186	Valier, *Franklin*	1942	10	0	500	500	0	0	1	1	0	0	1	0
187	West Frankfort	1941	20	0	*x*	*x*	0	0	3	2	0	0	3	0
188			*x*	0	*x*	*x*	0	0	2	1	0	0	2	0
189			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
190	Whittington, *Franklin*	1939	10	0	21,000	5,000	0	0	1	0	0	0	1	0
191	Inman, *Gallatin*	1940	60	0	28,000	11,000	0	0	5	1	0	0	5	0
192			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
193			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
194			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
195			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
196	Inman East, *Gallatin*	1940	530	0	982,000	526,000	0	0	61	22	0	0	61	0
197			*x*	0	*x*	*x*	0	0	3	0	0	0	3	0
198			*x*	0	*x*	*x*	0	0						
199			*x*	0	*x*	*x*	0	0	3	3	0	0	3	0
200			*x*	0	*x*	*x*	0	0	37	10	0	0	37	0

[26] Abandoned 1942.

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells											Depth, Avg. Ft.					
	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
145	0	1	*x*	*x*		36.6	0.29	McClosky	MisL	L	Por	2,000	2,027	12			
146	0	1	*x*	*x*		*x*	*x*	Pennsylvanian	Pen	S	Por	1,169	1,200	30	A	Dev	2,760
147	0	80													A	Dev	5,185
148	0	3	*x*	*x*		34.0	*x*	Bridgeport	Pen	S	Por	1,571	1,622	10			
149	0	10	*x*	*x*		34.0	*x*	Waltersburg	MisU	S	Por	2,365	2,375	10			
150			*x*	*x*		38.0	*x*	Bethel[28]	MisU	S	Por	2,935	2,949	14			
151	0	2	*x*	*x*		39.0	*x*	Aux Vases	MisU	S	Por	3,040	3,056	16			
152	0	60	*x*	*x*		40.0	0.18	McClosky	MisL	L	Por	3,108	3,119	11			
153	0	5						[27]									
154	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,054	3,066	12	A	MisU	3,261
155	0	18	*x*	*x*		40.5	0.33	McClosky	MisL	L	Por	3,266	3,325	8	D	MisL	3,350
156	0	12	*x*	*x*		36.6	0.23	Cypress	MisU	S	Por	2,620	2,640	12	D	MisL	3,175
157	0	1	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	3,418	3,425	7	A	MisL	3,496
158	0	0	*x*	*x*		*x*	*x*	Waltersburg	MisU	S	Por	2,403	2,407	4	A	MisL	3,294
159	0	2	*x*	*x*		39.1	*x*	McClosky	MisL	L	Por	3,341	3,353	12	D	MisL	3,353
160	0	3	*x*	*x*		35.8	0.31	McClosky	MisL	L	Por	3,093	3,188	6	A	MisL	3,269
161	0	9	*x*	*x*		38.4	0.21	McClosky	MisL	L	Por	2,490	2,497	7	A	MisL	2,525
162	0	22													A	MisL	2,462
163		15	*x*	*x*		38.0	*x*	Bethel	MisU	S	Por	2,305	2,316	11			
164			*x*	*x*		*x*	*x*	Aux Vases[28]	MisU	S	Por	2,360	2,374	14			
165	0	1	*x*	*x*		38.4	0.21	McClosky	MisL	L	Por	2,451	2,462	7			
166	0	6						[27]									
167	231	1,715			PM										A	St. Peter	4,679
168	62	880	*x*	280±		36.6	0.25	Cypress	MisU	S	Por	1,493	1,515	22			
169	1	322	*x*	335		37.8	0.24	Paint Creek	MisU	S	Por	1,530	1,545	15			
170	5	414	*x*	300		38.5	0.20	Bethel	MisU	S	Por	1,550	1,566	16			
171	30	45	*x*	1,280		28.2	0.48	Devonian	Dev	L	Por	3,000	3,025	15			
172	133	58						[27]									
173	0	183	*x*	*x*		34.4	0.31	Cypress	MisU	S	Por	1,581	1,600	16	A	Dev	3,375
174	0	13	*x*	*x*		34.0	0.23	Bethel	MisU	S	Por	1,885	1,906	6	D	MisU	1,906
175	0	3	*x*	*x*		32.0	*x*	Cypress	MisU	S	Por	2,839	2,860	10	A	MisL	3,263
176	0	229	*x*	*x*		41.7	0.12	Tar Springs	MisU	S	Por	2,100	2,150	34	A	MisL	3,203
177	0	11													D	MisL	2,890
178	0	3	*x*	*x*		*x*	*x*	Paint Creek	MisU	S	Por	2,595	2,605	10			
179	0	2	*x*	*x*		38.4	0.15	Bethel	MisU	S	Por	2,606	2,623	10			
180	0	2	*x*	*x*		39.0	0.15	Aux Vases	MisU	S	Por	2,689	2,700	10			
181	0	1	*x*	*x*		*x*	*x*	Levias	MisL	L	Por	2,743	2,751	8			
182	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	2,780	2,788	7			
183	0	2	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	2,783	2,792	5			
184	0	3	*x*	*x*		39.0	*x*	Aux Vases	MisU	S	Por	2,701	2,708	7	D	MisL	2,926
185	0	15	*x*	*x*		37.8	0.16	McClosky	MisL	L	Por	3,121	3,136	10	A	MisL	3,136
186	0	1	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	2,713	2,725	12	A	MisL	2,725
187	0	3													D	MisL	2,989
188	0	2	*x*	*x*		38.4	0.13	Tar Springs	MisU	S	Por	2,054	2,080	14			
189	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	2,698	2,713	15			
190	0	1	*x*	*x*		37.6	0.24	McClosky-St. Louis	MisL	L	Por	2,869	3,068	9	D	MisL	3,068
191	0	5													D	MisL	3,010
192	0	2	*x*	*x*		36.0	*x*	Palestine	MisU	S	Por	1,832	1,842	10			
193	0	1	*x*	*x*		*x*	*x*	Waltersburg	MisU	S	Por	1,990	2,001	10			
194	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	2,743	2,788	13			
195	0	1	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	2,730	2,742	10			
196	0	61													A	MisL	2,915
197	0	3	*x*	*x*		24.4	0.31	Pennsylvanian	Pen	S	Por	780	792	12			
198			*x*	*x*		*x*	*x*	Clore[28]	MisU	L	Por	1,725	1,737	12			
199	0	3	*x*	*x*		*x*	*x*	Waltersburg	MisU	S	Por	1,980	2,003	23			
200	0	37	*x*	*x*		34.6	0.24	Tar Springs	MisU	S	Por	2,082	2,097	15			

[28] Producing in combination wells.

TABLE 1.—(*Continued*)

Line Number	Field, County	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
									Completed to End of 1942	During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942		Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
201			*x*	0	*x*	*x*	0	0	8	2	0	0	8	0
202			*x*	0	*x*	*x*	0	0	3	0	0	0	3	0
203									7	7	0	0	7	0
204	Inman North, *Gallatin*	1941	30	0	9,000	4,000	0	0	3	1	0	0	3	0
205			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
206			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
207	Inman West, *Gallatin*	1942	90	0	32,000	32,000	0	0	5	5	0	0	5	0
208	Junction, *Gallatin*	1939	150	0	177,000	9,000	0	0	14	0	0	0	14	0
209	Omaha, *Gallatin*	1940	260	10	626,000	256,000	*x*	*x*	21	1	0	0	20	1
210			*x*	0	*x*	*x*	0	0	17	0	0	0	17	0
211			*x*	10	*x*	*x*	*x*	*x*	4	1	0	0	3	1
212	Belle Prairie, *Hamilton*	1940	20	0	59,000	24,000	0	0	2	0	0	0	2	0
213	Blairsville, *Hamilton*	1942	220	0	55,000	55,000	0	0	10	10	0	0	10	0
214			*x*	0	*x*	*x*	0	0	9	9	0	0	9	0
215			*x*	0	*x*	*x*	0	0						
216			*x*	0	*x*	*x*	0	0						
217									1	1	0	0	1	0
218	Bungay, *Hamilton*	1941	10	0	5,500	2,500	0	0	1	0	0	0	1	0
219	Dahlgren, *Hamilton*	1941	540	0	808,000	127,000	0	0	42	0	2	0	40	0
220	Dale-Hoodville Consolidated, *Hamilton*	1940	4,310	0	12,226,000	5,273,000	0	0	364	73	0	0	363	0
221			*x*	0	*x*	*x*	0	0	35	8	0	0	35	0
222			*x*	0	*x*	*x*	0	0	87	3	0	0	87	0
223			*x*	0	*x*	*x*	0	0	172	58	0	0	172	0
224			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
225			*x*	0	*x*	*x*	0	0	24	0	0	0	23	0
226									45	3	0	0	45	0
227	Rural Hill, *Hamilton*	1941	1,780	0	5,341,000	3,726,000	0	0	172	77	1	0	171	0
228			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
229			*x*	0	*x*	*x*	0	0	78	39	1	0	77	0
230			*x*	0	*x*	*x*	0	0	8	3	0	0	8	0
231			*x*	0	*x*	*x*	0	0						
232			*x*	0	*x*	*x*	0	0	25	6	0	0	25	0
233									60	28	0	0	60	0
234	Walpole, *Hamilton*	1941	630	0	911,000	703,000	0	0	33	15	0	0	33	0
235			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
236			*x*	0	*x*	*x*	0	0	32	14	0	0	32	0
237	Elkville, *Jackson*	1941	10	0	1,000	500	0	0	1	0	0	0	1	0
238	Boos North, *Jasper*	1940	1,020	0	1,649,000	654,000	0	0	60	14	2	0	58	0
239	Hidalgo, *Jasper*	1940	20	0	9,000	2,000	0	0	1	0	0	0	1	0
240	Ste. Marie, *Jasper*	1941	430	0	330,000	314,000	0	0	20	17	0	0	20	0
241	Coil West, *Jefferson*	1942	10	0	1,000	1,000	0	0	1	1	0	0	1	0
242	Cravat, *Jefferson*	1939	100	0	166,000	41,000	0	0	11	0	0	0	11	0
243	King, *Jefferson*	1942	80	0	31,000	31,000	0	0	5	5	0	0	5	0
244			*x*	0	*x*	*x*	0	0	3	3	0	0	3	0
245			*x*	0	*x*	*x*	0	0						
246			*x*	0	*x*	*x*	0	0						
247									2	2	0	0	2	0
248	Markham City, *Jefferson*	1942	320	0	160,000	160,000	0	0	12	12	0	0	12	0
249			*x*	0	*x*	*x*	0	0						
250			*x*	0	*x*	*x*	0	0	11	11	0	0	11	0
251									1	1	0	0	1	0
252	Roaches, *Jefferson*	1938	160	0	388,000	54,000	0	0	10	0	0	0	10	0
253	Woodlawn, *Jefferson*	1940	1,210	0	5,531,000	2,998,000	0	0	148	11	0	2	146	0
254	Dix, *Jefferson, Marion*	1938	1,470	0	3,011,000	651,000	0	0	81	5	0	0	81	0
255			*x*	0	*x*	*x*	0	0	80	4	0	0	80	0
256			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
257	Kell, *Jefferson, Marion*	1942	10	0	*x*	*x*	0	0	1	1	0	0	1	0

TABLE I.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells		Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
	Flowing	Artificial Lift										Top Prod. Zone	Bottoms Prod. Wells				
201	0	8	*x*	*x*		35.2	0.23	Cypress	MisU	S	Por	2,430	2,440	10			
202	0	3	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	2,804	2,910	10			
203	0	7						[27]									
204	0	3													D	MisL	3,020
205	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	2,816	2,841	25			
206	0	2	*x*	*x*		36.6	0.19	McClosky	MisL	L	Por	2,850	3,020	15			
207	0	5	*x*	*x*		38.0	*x*	Weiler	MisU	S	Por	2,482	2,500	17	D	MisL	2,990
208	0	14	*x*	*x*		37.2	0.22	Waltersburg	MisU	S	Por	1,763	1,804	15	D	MisL	2,711
209	0	20													D	MisL	3,578
210	0	17	*x*	*x*		25.9	0.23	Palestine	MisU	S	Por	1,690	1,710	20			
211	0	3	*x*	*x*		27.0	0.24	Tar Springs	MisU	S	Por	1,880	1,890	10			
212	0	2	*x*	*x*		37.0	0.12	McClosky	MisL	L	Por	3,467	3,578	6	D	MisL	3,578
213	0	10													D	MisL	3,531
214	0	9	*x*	*x*		38.1	*x*	Aux Vases	MisU	S	Por	3,290	3,312	12			
215			*x*	*x*		*x*	*x*	Levias[28]	MisL	L	Por	3,340	3,350	10			
216			*x*	*x*		*x*	*x*	McClosky[28]	MisL	L	Por	3,440	3,447	7			
217	0	1	*x*	*x*				[27]									
218	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,275	3,290	15	D	MisL	3,513
219	0	40	*x*	*x*		38.7	0.18	McClosky	MisL	L	Por	3,337	3,359	10	A	MisL	3,382
220	22	341			PM										D	MisL	3,314
221	0	35	*x*	*x*		37.6	0.25	Cypress	MisU	S	Por	2,678	2,708	18			
222	0	87	*x*	*x*		39.0	0.19	Bethel	MisU	S	Por	2,890	2,910	20			
223	20	152	*x*	*x*		38.5	0.39	Aux Vases	MisU	S	Por	2,970	3,000	30			
224	0	1	*x*	*x*		*x*	*x*	Levias	MisL	L	Por	3,140	3,163	13			
225	0	23	*x*	*x*		39.0	*x*	McClosky	MisL	L	Por	3,150	3,224	10			
226	2	43						[27]									
227	25	146													A	MisL	3,451
228	0	1	*x*	*x*		*x*	*x*	Cypress	MisU	S	Por	2,707	2,729	22			
229	9	68	*x*	*x*		38.0	0.15	Aux Vases	MisU	S	Por	3,135	3,160	25			
230	0	8	*x*	*x*		*x*	*x*	Levias	MisL	L	Por	3,200	3,230	30			
231			*x*	*x*		38.6	*x*	Rosiclare[28]	MisL	L	Por	3,230	3,260	15			
232	4	21	*x*	*x*		38.6	0.19	McClosky	MisL	L	Por	3,260	3,320	22			
233	12	48						[27]									
234	0	33													A	MisL	3,289
235	0	1	*x*	*x*		36.1	*x*	Tar Springs	MisU	S	Por	2,464	2,478	8			
236	0	32	*x*	*x*		36.3	*x*	Aux Vases	MisU	S	Por	3,050	3,085	30			
237	0	1	*x*	*x*		35.8	0.22	Paint Creek Stray	MisU	S	Por	2,000	2,011	11	D	MisL	2,387
238	0	58	*x*	*x*		38.6	0.20	McClosky	MisL	L	Por	2,791	2,834	8	A	MisL	2,950
239	0	1	*x*	*x*		38.6	0.20	McClosky	MisL	L	Por	2,560	2,607	8	N	Dev	4,139
240	0	20	*x*	*x*		40.2	0.14	McClosky	MisL	L	Por	2,823	2,833	8	A	MisL	2,935
241	0	1	*x*	*x*		*x*	*x*	Levias-McClosky	MisL	L	Por	2,791	2,856	16	A	MisL	2,981
242	0	11	*x*	*x*		35.4	0.23	Bethel	MisU	S	Por	2,066	2,077	11	D	MisL	2,356
243	0	5													A	MisL	2,928
244	0	3	*x*	*x*		38.6	0.17	Aux Vases	MisU	S	Por	2,740	2,762	22			
245			*x*	*x*		*x*	*x*	Levias[28]	MisL	L	Por	2,771	2,782	11			
246			*x*	*x*		*x*	*x*	McClosky[28]	MisL	L	Por	2,823	2,830	7			
247	0	2						[27]									
248	0	12													A	MisL	3,214
249			*x*	*x*		*x*	*x*	Levias[28]	MisL	L	Por	3,060	3,065	5			
250	0	11	*x*	*x*		38.0	*x*	McClosky	MisL	L	Por	3,065	3,070	5			
251	0	1						[27]									
252	0	10	*x*	*x*		37.0	0.22	Rosiclare-McClosky	MisL	L	Por	2,187	2,257	22	D	MisL	2,326
253	0	146	*x*	*x*		37.8	0.16	Bethel	MisU	S	Por	1,960	1,984	24	A	MisL	2,366
254	0	81			PM										A	Dev	3,650
255	0	80	*x*	275		39.0	0.23	Bethel	MisU	S	Por	1,948	1,961	13			
256	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	2,101	2,109	8			
257	0	1	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	2,625	2,627	2	A	MisL	2,720

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	During 1942		End of 1942		
										Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
258	Elk Prairie, *Jefferson*	1938[29]	10	0	700	0	0	0	1	0	0	0	0	0
259	Ina, *Jefferson*	1938[30]	10	0	15,000	0	0	0	1	0	0	0	0	0
260	Marcoe, *Jefferson*	1938[31]	20	0	12,500	0	0	0	2	0	0	0	0	0
261	Ruark, *Lawrence*	1941	10	0	*x*	*x*	0	0	1	0	0	0	1	0
262	Russellville gas, *Lawrence*	1937	0	1,670	0	0	4,290	1,472	54	5	0	0	0	53
263			0	1,600	0	0	*x*	*x*	11	3	0	0	0	11
264			0	270	0	0	*x*	*x*	43	2	0	0	0	42
265	St. Francisville East, *Lawrence*	1941	90	0	47,000	*x*	*x*	*x*	9	6	0	0	9	0
266	Carlinville North, *Macoupin*	1941	30	0	*x*	350	0	0	3	0	0	0	3	0
267	Plainview, *Macoupin*	1942	10	0	500	500	0	0	1	1	0	0	1	0
268	St. Jacob, *Madison*	1942	720	0	261,000	261,000	0	0	23	23	0	0	23	0
269	Alma, *Marion*	1941	20	0	27,000	19,000	0	0	3	1	1	0	2	0
270	Patoka, *Marion*	1937	910	0	2,839,000	343,000	0	0	130	0	0	0	105	0
271			885	0	*x*	*x*	0	0	127	0	0	0	102	0
272			25	0	*x*	*x*	0	0	3	0	0	0	3	0
273	Patoka East, *Marion*	1941	430	0	1,343,000	680,000	0	0	56	0	0	0	56	0
274			*x*	0	*x*	*x*	0	0	51	0	0	0	51	0
275			*x*	0	*x*	*x*	0	0	5	0	0	0	5	0
276	Salem, *Marion*	1938	9,120	0	167,052,000	14,786,000	0	0	2,418	2	24	51	2,312	0
277			9,120	0	*x*	*x*	0	0	460	1	9	6	441	0
278			*x*	0	*x*	*x*	0	0	152	0	5	0	145	0
279			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
280			*x*	0	*x*	*x*	0	0	550	0	5	16	505	0
281			*x*	0	*x*	*x*	0	0	8	0	0	0	8	0
282			5,000	0	32,821,000	1,291,000	0	0	541	0	5	12	424	0
283			1,000	0	1,713,000	795,000	0	0					99	0
284									706	0	0	17	689	0
285	Tonti, *Marion*	1939	380	0	5,589,000	859,000	0	0	55	0	1	0	54	0
286			*x*	0	*x*	*x*	0	0	5	0	0	0	5	0
287			*x*	0	*x*	*x*	0	0	15	0	0	0	15	0
288			*x*	0	*x*	*x*	0	0	29	0	1	0	28	0
289			*x*	0	1,378,000	128,000	0	0	6	0	0	0	6	0
290	Fairman, *Marion, Clinton*	1939	490	0	741,000	205,000	0	0	25	0	0	0	24	0
291	Mt. Olive, *Montgomery*	1942	10	0	*x*	*x*	0	0	1	1	0	0	1	0
292	Raymond, *Montgomery*	1940	30	0	3,000	500	0	0	3	0	0	0	2	0
293	Waggoner, *Montgomery*	1940	40	0	4,000	1,000	0	0	4	0	0	0	4	0
294	Tamaroa, *Perry*	1942	50	0	2,000	2,000	0	0	3	3	0	1	2	0
295	Amity, *Richland*	1942	10	0	1,000	1,000	0	0	1	1	0	0	1	0
296	Bonpas, *Richland*	1941	20	0	45,000	26,000	0	0	1	1	0	0	1	0
297	Bonpas West, *Richland*	1941	160	0	81,000	34,000	0	0	10	3	1	0	8	0
298			10	0	*x*	*x*	0	0	1	0	0	0	1	0
299			10	0	*x*	*x*	0	0	1	0	0	0	1	0
300			140	0	*x*	*x*	0	0	8	3	1	0	6	0
301	Noble, *Richland*	1937	4,200	10	14,660,000	2,548,000	*x*	*x*	291	27	0	9	255	1
302			*x*	0	*x*	*x*	0	0	114	25	0	4	109	0
303			*x*	10	*x*	*x*	*x*	*x*	177	2	0	5	146	1
304	Olney, *Richland*	1937	430	0	1,218,000	123,000	0	0	39	2	2	0	34	0
305	Schnell, *Richland*	1938	40	0	174,000	11,000	0	0	4	0	0	0	4	0
306	Stringtown, *Richland*	1941	140	0	116,000	101,000	0	0	8	5	0	0	8	0
307	Parkersburg, *Richland, Edwards*	1941	630	0	2,109,000	1,366,000	0	0	36	12	0	0	36	0
308			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
309			*x*	0	*x*	*x*	0	0	35	11	0	0	35	0
310	Dundas Consolidated, *Richland, Jasper*	1939	6,540	0	9,442,000	2,353,000	0	0	279	39	1	0	275	0

[29] Abandoned 1940.

[30] Abandoned 1941.

[31] Abandoned 1941.

TABLE I.—(*Continued*)

	Oil-production Methods, End of 1942		Reservoir Pressure,[c] Lb. per Sq. In.			Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells											Depth, Avg. Ft.					
Line Number	Flowing	Artificial Lift	Initial	Avg. at End of 1942	Repressuring Operation[d]	Gravity A.P.I. at 60°F., Weighted Average[b]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
258	0	0	x	x		x	x	McClosky	MisL	L	Por	2,718	2,751	7	D	MisL	2,958
259	0	0	x	x		36.4	0.20	St. Louis	MisL	L	Por	3,002	3,007	5	D	MisL	3,064
260	0	0	x	x		23.2	0.54	McClosky	MisL	L	Por	2,746	2,765	11	D	MisL	3,066
261	0	1	x	x		32.0	x	Buchanan	Pen	S	Por	1,514	1,531	14	D	MisL	2,320
262	0	0													A	Dev	3,133
263	0	0	x	x		x	x	Bridgeport	Pen	S	Por	760	793	15			
264	0	0	x	x		x	x	Buchanan	Pen	S	Por	1,108	1,119	11			
265	0	9	x	x		40.1	x	Bethel	MisU	S	Por	1,765	1,773	8	A	MisL	1,962
266	0	3	x	x		20.3	0.35	Pennsylvanian	Pen	S	Por	443	462	10	D	Pen	527
267	0	1	x	x		x	x	Pennsylvanian	Pen	S	Por	400	405	5	A	Pen	421
268	0	23	x	x		40.0	0.23	"Trenton"	Ord	L	Por	2,280	2,340	30	A	Ord	2,484
269	0	2	x	x		37.1	x	Bethel, Rosiclare	Mis U-L	S	Por	1,931	2,110	21	A	Dev	3,692
270	0	105													A	Dev	2,956
271	0	102	x	30		39.5	0.16	Bethel	MisU	S	Por	1,424	1,449	25			
272	0	3	x	50		40.9	0.31	Rosiclare	MisL	L	Por	1,562	1,572	10	A	MisL	1,737
273	0	56															
274	0	51	x	x		36.1	0.23	Cypress	MisU	S	Por	1,340	1,360	20			
275	0	5	x	x		36.1	0.23	Bethel	MisU	S	Por	1,466	1,478	12	A	Prairie du Chien	5,655
276	0	2,312			PM												
277	0	441	x	x		38.5	0.20	Bethel	MisU	S	Por	1,797	1,838	40			
278	0	145	x	x		38.6	0.21	Aux Vases	MisU	S	Por	1,813	1,865	28			
279	0	1	x	x		39.0	x	Rosiclare	MisL	S	Por	1,950	1,965	5			
280	0	505	x	x		39.0	x	McClosky	MisL	L	Por	1,975	2,048	17			
281	0	8	x	x		39.0	x	Salem	MisL	L	Por	2,156	2,222	17			
282	0	424	x	x		42.1	0.28	Devonian	Dev	L	Por	3,350	3,440	60			
283	0	99	x	x		42.0	x	Trenton	Ord	L	Por	4,500	4,625	50			
284	0	689						27							D	Dev	3,547
285	0	54	x	x													
286	0	5	x	x		39.0	x	Bethel	MisU	S	Por	1,928	1,948	20			
287	0	15	x	x		39.0	x	Aux Vases	MisU	S	Por	2,003	2,038	30			
288	0	28	x	x		39.4	0.21	McClosky	MisL	L	Por	2,134	2,149	15			
289	0	6	x	x		41.0	x	Devonian	Dev	L	Por	3,490	3,505	15	D	"Trenton"	4,100
290	0	24	x	x		38.2	0.21	Bethel	MisU	S	Por	1,462	1,479	8	D	Pen	602
291	0	1	x	x		x	x	Pennsylvanian	Pen	S	Por	600	602	2	D	Pen	598
292	0	2	x	x		34.8	0.22	Pennsylvanian	Pen	S	Por	580	598	18	D	Dev	1,784
293	0	4	x	x		28.0	0.21	Pennsylvanian	Pen	S	Por	611	625	14	A	MisL	1,530
294	0	2	x	x		x	x	Weiler	MisU	S	Por	1,127	1,140	10	A	MisL	3,089
295	0	1	x	x		x	x	McClosky	MisL	L	Por	2,961	2,968	7	D	MisL	3,200
296	0	1	x	x		37.8	0.23	McClosky	MisL	L	Por	3,120	3,200	8	D	MisL	3,198
297	0	8															
298	0	1	x	x		x	x	Bethel	MisU	S	Por	2,930	2,970	10			
299	0	1	x	x		x	x	Levias	MisL	L	Por	3,070	3,080	10			
300	0	6	x	x		38.1	x	McClosky	MisL	L	Por	3,130	3,170	6	A	MisL	3,201
301	0	237															
302	0	109	x	865±		38.0	0.27	Cypress	MisU	S	Por	2,544	2,639	20			
303	0	128	x	x		39.0	0.17	McClosky	MisL	L	Por	2,957	3,003	10	A	MisL	3,222
304	0	34	x	x		37.2	0.19	McClosky	MisL	L	Por	3,052	3,073	9	D	MisL	3,120
305	0	4	x	x		37.0	0.19	McClosky	MisL	L	Por	3,012	3,068	6	D	MisL	3,081
306	0	8	x	x		39.8	0.24	McClosky	MisL	L	Por	3,025	3,040	8	A	MisL	3,200
307	0	36															
308	0	1	x	x		x	x	Weiler	MisU	S	Por	2,832	2,850	18			
309	0	35	x	x		38.0	0.31	McClosky	MisL	L	Por	3,120	3,130	12	A	Dev	4,584
310	0	275															

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
311			30	0	*x*	*x*	0	0	4	3	0	0	4	0
312			20	0	*x*	*x*	0	0	2	1	0	0	2	0
313			*x*	0	*x*	*x*	0	0						
314			6,500	0	*x*	*x*	0	0	268	32	1	0	264	0
315			60	0	*x*	*x*	0	0	5	3	0	0	5	0
316	Dundas East, *Richland, Jasper*	1942	240	0	113,000	113,000	0	0	11	11	0	0	11	0
317	Eldorado, *Saline*..........	1941	20	0	4,000	3,000	0	0	2	0	0	0	2	0
318	Lakewood, *Shelby*.........	1941	20	0	16,000	8,000	0	0	2	0	0	0	2	0
319			10	0	*x*	*x*	0	0	1	0	0	0	1	0
320			10	0	*x*	*x*	0	0	1	0	0	0	1	0
321	Stewardson, *Shelby*........	1939	30	0	31,000	9,000	0	0	3	0	0	0	3	0
322	Friendsville, *Wabash*.......	1942	60	0	10,000	10,000	0	0	7	7	1	0	6	0
323			*x*	0	*x*	*x*	0	0	3	3	1	0	2	0
324			*x*	0	*x*	*x*	0	0	3	3	0	0	3	0
325			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
326	Keensburg Consolidated, *Wabash*	1939	2,630	0	7,766,000	1,704,000	0	0	330	28	4	5	314	0
327			*x*	0	*x*	*x*	0	0	18	2	0	2	16	0
328			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
329			*x*	0	*x*	*x*	0	0	4	0	0	0	4	0
330			*x*	0	*x*	*x*	0	0	9	2	0	0	9	0
331			*x*	0	*x*	*x*	0	0	247	9	4	2	234	0
332			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
333			*x*	0	*x*	*x*	0	0	8	2	0	0	8	0
334			*x*	0	*x*	*x*	0	0	4	2	0	0	4	0
335			*x*	0	*x*	*x*	0	0	23	4	0	1	22	0
336									14	6	0	0	14	0
337	Keensburg East, *Wabash*.	1939	20	0	*x*	*x*	0	0	3	0	1	0	2	0
338	Maud, *Wabash*............	1940	250	0	198,000	50,000	0	0	20	0	1	0	17	0
339			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
340			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
341			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
342			*x*	0	*x*	*x*	0	0	15	0	1	0	12	0
343									1	0	0	0	1	0
344	Mt. Carmel, *Wabash*......	1940	1,260	0	2,739,000	1,019,000	0	0	199	10	3	1	193	0
345			*x*	0	*x*	*x*	0	0	30	1	1	0	27	0
346			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
347			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
348			*x*	0	*x*	*x*	0	0	130	8	2	1	127	0
349			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
350			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
351			*x*	0	*x*	*x*	0	0	23	0	0	0	23	0
352									11	1	0	0	11	0
353	Mt. Carmel West, *Wabash*	1939	20	0	*x*	*x*	0	0	2	0	0	0	1	0
354	Patton, *Wabash*..........	1940[32]	40	0	3,500	1,500	0	0	4	0	1	0	3	0
355			30	0	*x*	*x*	0	0	3	0	1	0	2	0
356			10	0	*x*	*x*	0	0	1	0	0	0	1	0
357	Lancaster, *Wabash, Lawrence*	1940	340	0	485,000	45,000	0	0	30	2	2	3	20	0
358			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
359			*x*	0	*x*	*x*	0	0	29	1	2	3	19	0
360	Cordes, *Washington*......	1939	1,440	0	2,161,000	437,000	0	0	131	3	1	1	129	0
361	Dubois, *Washington*......	1939	140	0	84,000	27,000	0	0	10	1	0	0	10	0
362	Dubois West, *Washington*	1942	10	0	2,000	2,000	0	0	1	1	0	0	1	0
363	Irvington, *Washington*....	1940	800	0	2,303,000	749,000	0	0	83	9	1	0	82	0
364			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
365			*x*	0	*x*	*x*	0	0	74	8	1	0	73	0
366			*x*	0	*x*	157,000	0	0	7	0	0	0	7	0
367									1	0	0	0	1	0
368	McKinley, *Washington*...	1940	60	0	136,000	45,000	0	0	6	0	1	0	5	0
369			50	0	*x*	39,000	0	0	5	0	1	0	4	0
370			10	0	*x*	6,000	0	0	1	0	0	0	1	0
371	Aden North, *Wayne*......	1938	1,100	0	2,758,000	272,000	0	0	66	1	1	0	61	0

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[32] Biehl sand production since 1936, formerly included in the Allendale pool.

TABLE I.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells: Flowing	Number of Wells: Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[b]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.: Top Prod. Zone	Depth, Avg. Ft.: Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
311	0	4	x	x		37.0	x	Cypress	MisU	S	Por	2,570	2,590	23			
312	0	2	x	x		38.0	x	Aux Vases	MisU	S	Por	2,705	2,738	10			
313			x	x		x	x	Rosiclare[28]	MisL	S	Por	2,847	2,860	6			
314	0	264	x	x		38.4	0.17	McClosky	MisL	L	Por	2,869	2,920	13			
315	0	5						[27]									
316	0	11	x	x		x	x	McClosky	MisL	L	Por	2,999	3,007	8	A	MisL	3,106
317	0	2	x	x		x	x	McClosky	MisL	L	Por	2,943	2,950	5	A	MisL	3,000
318	0	2	x	x											D	MisL	1,875
319	0	1	x	x		29.6	x	Bethel	MisU	S	Por	1,692	1,700	8			
320	0	1	x	x		31.7	0.23	Aux Vases	MisU	S	Por	1,723	1,735	9			
321	0	3	x	x		37.8	0.18	Aux Vases	MisU	S	Por	1,942	1,969	5	D	MisU	1,969
322	0	6													A	MisU	2,686
323	0	2	x	x		x	x	Biehl	Pen	S	Por	1,759	1,785	21			
324	0	3	x	x		37.0	x	Cypress	MisU	S	Por	2,289	2,301	12			
325	0	1	x	x		x	x	Bethel	MisU	S	Por	2,464	2,480	10			
326	0	314													A	MisL	3,065
327	0	16	x	x		38.0	x	Biehl	Pen	S	Por	1,719	1,733	14			
328	0	2	x	x		x	x	Clore	MisU	S	Por	1,811	1,823	9			
329	0	4	x	x		x	x	Palestine	MisU	S	Por	1,830	1,846	16			
330	0	9	x	x		x	x	Tar Springs	MisU	S	Por	2,060	2,075	15			
331	0	234	x	x		38.6	0.29	Cypress	MisU	S	Por	2,444	2,462	18			
332	0	1	x	x		x	x	Paint Creek	MisU	S	Por	2,550	2,570	12			
333	0	8	x	x		36.6	x	Bethel	MisU	S	Por	2,570	2,588	18			
334	0	4	x	x		x	x	Aux Vases	MisU	S	Por	2,760	2,790	30			
335	0	22	x	x		37.9	0.38	McClosky	MisL	L	Por	2,790	2,797	7			
336	0	14						[27]									
337	0	2	x	x		37.6	0.26	McClosky	MisL	L	Por	2,703	2,714	6	D	MisL	2,714
338	0	17													D	MisL	2,671
339	0	2	x	x		37.7	x	Waltersburg	MisU	S	Por	1,935	1,956	21			
340	0	1	x	x		x	x	Mississippian U	MisU	S	Por	2,120	2,132	12			
341	0	1	x	x		x	x	Rosiclare	MisL	S	Por	2,639	2,650	9			
342	0	12	x	x		38.0	0.30	McClosky	MisL	L	Por	2,650	2,658	8			
343	0	1						[27]									
344	0	193													A	MisL	2,477
345	0	27	x	x		32.0	x	Biehl	Pen	S	Por	1,450	1,464	14			
346	0	1	x	x		x	x	Palestine	MisU	S	Por	1,540	1,550	10			
347	0	1	x	x		x	x	Tar Springs	MisU	S	Por	1,790	1,794	4			
348	0	127	x	x		38.4	x	Cypress	MisU	S	Por	2,033	2,048	15			
349	0	1	x	x		x	x	Bethel	MisU	S	Por	2,100	2,115	15			
350	0	2	x	x		36.6	0.36	Rosiclare	MisL	S	Por	2,360	2,364	4			
351	0	23	x	x		38.4	0.42	McClosky	MisL	L	Por	2,370	2,380	10			
352	0	11						[27]									
353	0	1	x	x		x	x	Tar Springs	MisU	S	Por	1,940	1,955	15	D	MisL	2,556
354	0	3													A	MisL	2,313
355	0	2	x	x		x	x	Biehl	Pen	S	Por	1,470	1,485	15			
356	0	1	x	x		x	x	McClosky	MisL	L	Por	2,309	2,313	4			
357	0	20													A	MisL	2,765
358	0	1	x	x		x	x	Bethel	MisU	S	Por	2,533	2,550	11			
359	0	18	x	x		39.8	0.28	McClosky	MisL	L	Por	2,683	2,700	9			
360	1	128	x	x		37.4	0.19	Bethel	MisU	S	Por	1,259	1,285	17	A	MisL	1,550
361	0	10	x	x		38.0	0.26	Bethel	MisU	S	Por	1,359	1,370	11	D	Dev	3,537
362	0	1	x	x		x	x	Bethel	MisU	S	Por	1,346	1,352	6	A	MisL	1,685
363	0	82													A	Dev	3,150
364	0	1	x	x		x	x	Weiler	MisU	S	Por	1,386	1,410	14			
365	0	73	x	x		37.6	0.16	Bethel	MisU	S	Por	1,537	1,550	10			
366	0	7	x	x		39.0	0.27	Devonian	Dev	L	Por	3,092	3,150	5			
367	0	1						[27]									
368	0	5													D	Dev	2,567
369	0	4	x	x		44.1	0.18	Renault	MisU	S	Por	982	996	14			
370	0	1	x	x		41.7	x	Devonian	Dev	L	Por	2,250	2,272	4			
371	0	61	x	x		39.0	0.17	McClosky	MisL	L	Por	3,321	3,341	12	A	Dev	5,393

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
372	Barnhill, *Wayne*........	1939	880	0	1,582,000	122,000	0	0	64	0	3	0	59	0
373			*x*	0	*x*	*x*	0	0	61	0	3	0	56	0
374			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
375									2	0	0	0	2	0
376	Barnhill East,[33] *Wayne*...	1939	60	0	35,000	*x*	0	0	5	1	0	0	4	
377			*x*	0	*x*	*x*	0	0	2	1	0	0	1	0
378			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
379			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
380	Boyleston, *Wayne*........	1938	1,920	0	3,023,000	672,000	0	0	114	14	3	0	111	0
381			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
382			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
383			*x*	0	*x*	*x*	0	0	109	11	3	0	106	0
384									3	2	0	0	3	0
385	Cisne, *Wayne*............	1937	920	0	2,640,000	178,000	0	0	48	1	0	0	46	0
386					*x*	*x*	0	0	2	0	0	0	2	0
387					*x*	*x*	0	0	1	0	0	0	1	0
388					*x*	*x*	0	0	45	1	0	0	43	0
389	Cisne North, *Wayne*......	1942	20	0	2,000	2,000	0	0	1	1	0	0	1	0
390	Coil, *Wayne*.............	1942	340	0	253,000	253,000	0	0	14	14	1	0	13	0
391			*x*	0	*x*	*x*	0	0	12	12	1	0	11	0
392			*x*	0	*x*	*x*	0	0	2	2	0	0	2	0
393	Covington, *Wayne*........	1942	890	0	1,070,000	1,070,000	0	0	32	32	0	0	32	0
394			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
395			*x*	0	*x*	*x*	0	0	4	4	0	0	4	0
396			*x*	0	*x*	*x*	0	0	25	25	0	0	25	0
397									2	2	0	0	2	0
398	Fairfield, *Wayne*.........	1942	10	0	1,000	1,000	0	0	1	1	0	0	1	0
399	Geff, *Wayne*.............	1941	290	0	120,000	116,000	0	0	15	14	0	0	15	0
400			*x*	0	*x*	*x*	0	0	12	12	0	0	12	0
401			*x*	0	*x*	*x*	0	0	3	2	0	0	3	0
402	Geff West, *Wayne*........	1942	240	0	12,000	12,000	0	0	3	3	0	0	3	0
403	Goldengate, *Wayne*.......	1939	40	0	17,000	*x*	0	0	3	1	0	2	1	0
404			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
405			*x*	0	*x*	*x*	0	0	2	0	0	2	0	0
406	Johnsonville, *Wayne*......	1941	3,790	0	10,668,000	5,136,000	0	0	247	30	0	0	247	0
407			*x*	0	*x*	*x*	0	0	33	14	0	0	33	0
408			*x*	0	*x*	*x*	0	0						
409			*x*	0	*x*	*x*	0	0	207	11	0	0	207	0
410									7	5	0	0	7	0
411	Johnsonville South, *Wayne*	1942	20	0	2,000	2,000	0	0	2	2	0	0	2	0
412			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
413			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
414	Johnsonville West,[34] *Wayne*	1942	10	0	*x*	*x*	0	0	1	1	1	0	0	0
415	Leech Township, *Wayne*..	1938	240	0	353,000	51,000	0	0	14	0	0	0	14	0
416	Mt. Erie, *Wayne*.........	1938	320	0	97,000	86,000	0	0	11	10	0	0	11	0
417			*x*	0	*x*	*x*	0	0	3	3	0	0	3	0
418			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
419			*x*	0	*x*	*x*	0	0	6	5	0	0	6	0
420									1	1	0	0	1	0
421	Mt. Erie South,[35] *Wayne*..	1939	10	0	9,000	2,000	0	0	2	1	0	0	1	0
422			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
423			*x*	0	*x*	*x*	0	0	1	0	0	0	0	0
424	Mayberry, *Wayne*........	1941	330	0	106,000	100,000	0	0	6	2	0	0	6	0
425	Rinard,[36] *Wayne*.........	1937	10	0	15,000	0	0	0	1	0	0	0	0	0
426	Sims, *Wayne*.............	1941	1,610	0	1,664,000	1,623,000	0	0	56	52	1	0	55	0
427			*x*	0	*x*	*x*	0	0	10	6	0	0	10	0
428			*x*	0	*x*	*x*	0	0						
429			*x*	0	*x*	*x*	0	0						
430			*x*	0	*x*	*x*	0	0	28	28	1	0	27	0
431									18	18	0	0	18	0
482	Sims North, *Wayne*...	1942	190	0	75,000	75,000	0	0	7	7	1	0	6	0

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[33] Barnhill East wells formerly part of Goldengate Pool.
[34] Abandoned 1942.
[35] Abandoned 1941, revived 1942.
[36] Abandoned 1939, revived August 1940.

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells											Depth, Avg. Ft.					
	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
372	0	59													A	MisL	3,855
373	0	56	*x*	*x*		37.6	0.17	McClosky	MisL	L	Por	3,385	3,411	11			
374	0	1	*x*	*x*		*x*	*x*	Salem	MisL	L	Por	3,792	3,855	*y*			
375	0	2	*x*	*x*				27									
376															D	MisL	3,532
377	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,238	3,350	12			
378	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	3,318	3,345	5			
379	0	2	*x*	*x*		34.4	0.18	McClosky	MisL	L	Por	3,377	3,399	7			
380	0	111													A	MisL	3494
381	0	1	*x*	*x*		*x*	*x*	Levias	MisL	L	Por	3,214	3,235	11			
382	0	1	*x*	*x*		40.2	0.14	Rosiclare	MisL	S	Por	3,250	3,260	4			
383	0	106	*x*	*x*		40.2	0.14	McClosky	MisL	L	Por	3,260	3,280	14			
384	0	3						27									
385	0	46													A	St. Peter	7,207
386	0	2	*x*	*x*		38.5	*x*	Aux Vases	MisU	S	Por	2,982	3,029	13			
387	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	3,010	3,160	4			
388	0	43	*x*	*x*		35.8	0.24	McClosky	MisL	L	Por	3,121	3,178	15			
389	0	1	*x*	*x*		39.0	*x*	McClosky	MisL	L	Por	3,170	3,185	10	A	MisL	3,237
390	0	13													A	MisL	3,180
391	0	11	*x*	*x*		37.1	0.20	Aux Vases	MisU	S	Por	2,860	2,876	16			
392	0	2	*x*	*x*		37.5	*x*	McClosky	MisL	L	Por	2,971	2,974	3			
393	0	32													D	MisL	3,324
394	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,115	3,133	18			
395	0	4	*x*	*x*		40.0	*x*	Levias	MisL	L	Por	3,209	3,220	5			
396	0	25	*x*	*x*		40.0	*x*	McClosky	MisL	L	Por	3,238	3,246	8			
397	0	2						27									
398	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,236	3,255	14	A	MisL	3,389
399	0	15													D	MisL	3,319
400	0	12	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,065	3,080	14			
401	0	3	*x*	*x*		29.4	*x*	McClosky	MisL	L	Por	3,135	3,180	3			
402	0	3	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	3,129	3,150	12	D	MisL	3,320
403	0	1													D	Dev	5,645
404	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	3,318	3,345	5			
405	0	0	*x*	*x*		34.4	0.18	McClosky	MisL	L	Por	3,377	3,399	7			
406	0	247													A	MisL	3,389
407	0	33	*x*	*x*		39.4	0.41	Aux Vases	MisU	S	Por	2,980	3,040	12			
408			*x*	*x*		*x*	*x*	Levias[28]	MisL	L	Por	3,040	3,070	10			
409	0	207	*x*	*x*		39.4	0.16	McClosky	MisL	L	Por	3,070	3,150	15			
410	0	7						27									
411	0	2													A	MisL	3,237
412	0	1	*x*	*x*		39.0	*x*	Aux Vases	MisU	S	Por	3,032	3,052	20			
413	0	1	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	3,212	3,215	3			
414	0	0	*x*	*x*		*x*	*x*	McClosky	MisL	L	Por	3,107	3,115	6	A	MisL	3,185
415	0	14	*x*	*x*		39.0	0.19	McClosky	MisL	L	Por	3,413	3,453	11	D	MisL	3,485
416	0	11													D	MisL	3,215
417	0	3	*x*	*x*		39.2	0.11	Aux Vases	MisU	S	Por	2,973	2,990	17			
418	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	3,068	3,075	7			
419	0	6	*x*	*x*		39.8	0.18	McClosky	MisL	L	Por	3,080	3,092	*y*			
420	0	1						27							D	MisL	3,380
421	0	1															
422	0	1	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	3,255	3,264	9			
423	0	0	*x*	*x*		31.7	*x*	McClosky	MisL	L	Por	3,265	3,279	11			
424	0	6	*x*	*x*		38.0	0.16	McClosky	MisL	L	Por	3,340	3,380	7	D	MisL	3,380
425	0	0	*x*	*x*		38.5	*x*	McClosky	MisL	L	Por	3,144	3,154	5	D	MisL	3,154
426	0	55													A	MisL	3,306
427	0	10	*x*	*x*		40.4	0.20	Aux Vases	MisU	S	Por	3,030	3,045	15			
428			*x*	*x*		39.1	*x*	Levias[28]	MisL	L	Por	3,112	3,117	5			
429			*x*	*x*		*x*	*x*	Rosiclare[28]	MisL	S	Por	3,130	3,145	8			
430	0	27	*x*	*x*		39.1	*x*	McClosky	MisL	L	Por	3,170	3,220	8			
431	0	18						27							A	MisL	3,209
432	0	6															

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres: Oil	Area Proved, Acres: Gas[b]	Total Oil Production, Bbl.: To End of 1942	Total Oil Production, Bbl.: During 1942	Total Gas Production, Millions Cu. Ft.: To End of 1942	Total Gas Production, Millions Cu. Ft.: During 1942	Number of Oil and/or Gas Wells: Completed to End of 1942	During 1942: Completed	During 1942: Abandoned	End of 1942: Temporarily Shut Down	End of 1942: Producing Oil[c]	End of 1942: Producing Gas[c]
433			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
434			*x*	0	*x*	*x*	0	0	3	3	1	0	2	0
435			*x*	0	*x*	*x*	0	0	2	2	0	0	2	0
436									1	1	0	0	1	0
437	Aden, *Wayne, Hamilton*	1938	370	0	530,000	141,000	0	0	10	1	1	0	9	0
438			*x*	0	*x*	*x*	0	0						
439			*x*	0	*x*	*x*	0	0	9	0	1	0	8	0
440									1	1	0	0	1	0
441	Burnt Prairie, *White*	1940	270	0	327,000	73,000	0	0	20	0	0	0	20	0
442			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
443			*x*	0	*x*	*x*	0	0	18	0	0	0	18	0
444	Carmi, *White*	1940	30	0	4,000	2,000	0	0	2	1	1	0	1	0
445			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
446			*x*	0	*x*	*x*	0	0	1	0	1	0	0	0
447	Carmi North, *White*	1942	50	0	21,000	21,000	0	0	3	3	0	0	3	0
448	Centerville, *White*	1940	60	0	156,000	41,000	0	0	5	0	0	0	5	0
449	Centerville East, *White*	1941	500	0	503,000	485,000	0	0	36	30	1	0	35	0
450			*x*	0	*x*	*x*	0	0	20	16	1	0	19	0
451			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
452			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
453			*x*	0	*x*	*x*	0	0	4	4	0	0	4	0
454			*x*	0	*x*	*x*	0	0						
455			*x*	0	*x*	*x*	0	0	9	8	0	0	9	0
456									1	1	0	0	1	0
457	Concord, *White*	1942	10	0	8,000	8,000	0	0	1	1	0	0	1	0
458	Epworth, *White*	1941	100	0	100,000	86,000	0	0	10	6	1	0	9	0
459			*x*	0	*x*	*x*	0	0	2	1	0	0	2	0
460			*x*	0	*x*	*x*	0	0	7	5	1	0	6	0
461			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
462	Grayville West, *White*	1941	30	0	23,000	14,000	0	0	3	0	1	0	2	0
463			10	0	*x*	*x*	0	0	1	0	0	0	1	0
464			20	0	*x*	*x*	0	0	2	0	1	0	1	0
465	Herald, *White*	1940	80	0	49,000	26,000	0	0	8	3	3	0	5	0
466			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
467			*x*	0	*x*	*x*	0	0	3	0	1	0	2	0
468			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
469			*x*	0	*x*	*x*	0	0	2	2	2	0	0	0
470	Iron, *White*	1940	770	0	2,390,000	472,000	0	0	64	1	3	0	61	0
471			*x*	0	*x*	*x*	0	0	5	0	1	0	4	0
472			*x*	0	*x*	*x*	0	0	33	0	1	0	32	0
473			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
474			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
475			*x*	0	*x*	*x*	0	0	20	0	1	0	19	0
476									3	0	0	0	3	0
477	Maunie, *White*	1941	20	0	13,000	9,000	0	0	2	0	0	0	2	0
478	Maunie North, *White*	1941	40	0	20,000	14,000	0	0	5	2	0	1	4	0
479			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
480			*x*	0	*x*	*x*	0	0	4	2	0	1	3	0
481	Maunie South, *White*	1939	670	0	982,000	608,000	0	0	69	17	2	0	67	0
482			*x*	0	*x*	*x*	0	0	5	1	0	0	5	0
483			*x*	0	*x*	*x*	0	0	34	4	2	0	32	0
484			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
485			*x*	0	*x*	*x*	0	0	17	9	0	0	17	0
486			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
487			*x*	0	*x*	*x*	0	0	6	1	0	0	6	0
488			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
489			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
490									3	1	0	0	3	0
491	New Harmony Consolidated, *White*	1939	6,760	0	18,957,000	7,251,000	0	0	710	61	5	0	704	0
492			*x*	0	*x*	*x*	0	0	7	6	0	0	7	0

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation■	Character of Oil		Producing Formation							Structure[h]	Deepest Zone Tested to End of 1942	
	Number of Wells											Depth, Avg. Ft.					
	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.		Name	Depth of Hole, Ft.
433	0	1	x	x		x	x	Aux Vases	MisU	S	Por	3,131	3,141	10			
434	0	2	x	x		x	x	Rosiclare	MisL	S	Por	3,150	3,160	8			
435	0	2	x	x		37.5	0.19	McClosky	MisL	L	Por	3,183	3,190	4			
436	0	1						[27]									
437	0	9													A	MisL	3,460
438			x	x		x	x	Aux Vases[28]	MisU	S	Por	3,177	3,192	15			
439	0	8	x	x		40.0	x	McClosky	MisL	L	Por	3,287	3,337	7			
440	0	1						[27]									
441	0	20													D	MisL	3,432
442	0	2	x	x		x	x	Rosiclare	MisL	S	Por	3,260	3,404	9			
443	0	18	x	x		37.0	0.28	McClosky	MisL	L	Por	3,425	3,436	11			
444	0	1													D	MisL	3,236
445	0	1	x	x		x	x	Levias	MisL	L	Por	3,130	3,140	8			
446	0	0	x	x		x	x	McClosky	MisL	L	Por	3,148	3,167	4			
447	0	3	x	x		37.0	0.14	Aux Vases	MisU	S	Por	3,228	3,250	14	D	MisU	3,250
448	0	5	x	x		36.8	0.17	McClosky	MisL	L	Por	3,355	3,373	4	D	MisL	3,373
449	0	35													D	MisL	3,366
450	0	19	x	x		37.2	0.20	Tar Springs	MisU	S	Por	2,530	2,545	15			
451	0	1	x	x		x	x	Cypress	MisU	S	Por	2,915	2,925	10			
452	0	1	x	x		x	x	Bethel	MisU	S	Por	2,960	2,974	14			
453	0	4	x	x		x	x	Aux Vases	MisU	S	Por	3,083	3,094	11			
454			x	x		x	x	Levias[28]	MisL	L	Por	3,177	3,182	5			
455	0	9	x	x		40.0	x	McClosky	MisL	L	Por	3,264	3,276	12			
456	0	1						[27]									
457	0	1	x	x		x	x	Aux Vases	MisU	S	Por	2,904	2,914	10	A	MisU	3,080
458	0	9													D	MisL	3,195
459	0	2	x	x		x	x	Degonia	MisU	S	Por	2,092	2,108	6			
460	0	6	x	x		36.2	x	Clore	MisU	S	Por	2,072	2,109	18			
461	0	1	x	x		x	x	Palestine	MisU	S	Por	2,099	2,188	14			
462	0	2													D	MisL	3,273
463	0	1	x	x		37.0	x	Cypress	MisU	S	Por	2,870	2,890	20			
464	0	1	x	x		x	x	McClosky	MisL	L	Por	3,172	3,273	8			
465	0	5													A	MisL	3,173
466	0	2	x	x		28.0	x	Pennsylvanian	Pen	S	Por	1,565	1,571	6			
467	0	2	x	x		37.2	0.24	Tar Springs	MisU	S	Por	2,259	2,276	18			
468	0	1	x	x		x	x	Cypress	MisU	S	Por	2,654	2,664	10			
469	0	0	x	x		x	x	Bethel	MisU	S	Por	2,792	2,800	8			
470	0	61	x												A	MisL	3,142
471	0	4	x	x		36.4	x	Tar Springs	MisU	S	Por	2,425	2,440	6			
472	0	32	x	x		38.4	0.30	Hardinsburg	MisU	S	Por	2,537	2,556	18			
473	0	2	x	x		38.0	x	Cypress	MisU	S	Por	2,708	2,753	24			
474	0	1	x	x		x	x	Bethel	MisU	S	Por	2,792	2,800	8			
475	0	19	x	x		39.0	0.20	McClosky	MisL	L	Por	3,061	3,142	10			
476	0	3						[27]									
477	0	2	x	x		38.0	x	Palestine	MisU	S	Por	2,012	2,018	6	D	MisL	3,049
478	0	4													D	MisL	3,107
479	0	1	x	x		36.5	x	Bethel	MisU	S	Por	2,826	2,847	21			
480	0	3	x	x		x	x	McClosky	MisL	L	Por	3,075	3,092	6			
481	0	67													A	MisL	3,028
482	0	5	x	x		37.0	x	Pennsylvanian	Pen	S	Por	1,455	1,480	25			
483	0	32	x	x		33.8	0.28	Palestine	MisU	S	Por	2,020	2,038	18			
484	0	1	x	x		x	x	Waltersburg	MisU	S	Por	2,208	2,217	9			
485	0	17	x	x		38.0	x	Tar Springs	MisU	S	Por	2,254	2,268	14			
486	0	1	x	x		39.0	x	Cypress	MisU	S	Por	2,561	2,569	8			
487	0	6	x	x		x	x	Aux Vases	MisU	S	Por	2,844	2,866	22			
488	0	1	x	x		x	x	Levias	MisL	L	Por	2,865	2,880	3			
489	0	1	x	x		x	x	McClosky	MisL	L	Por	2,871	2,873	2			
490	0	3						[27]							A	MisL	3,219
491	0				PM												
492	0	7	x	x		x	x	Biehl	Pen	S	Por	1,830	1,870	40			

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
493			*x*	0	*x*	*x*	0	0	19	3	1	0	18	0
494			*x*	0	*x*	*x*	0	0	27	5	0	0	27	0
495			*x*	0	*x*	*x*	0	0	86	6	0	0	86	0
496			*x*	0	*x*	*x*	0	0	11	0	0	0	11	0
497			*x*	0	*x*	*x*	0	0	125	8	0	0	124	0
498			*x*	0	*x*	*x*	0	0	165	20	3	0	162	0
499			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
500			*x*	0	*x*	*x*	0	0	98	4	0	0	98	0
501									170	9	1	0	169	0
502	New Harmony South, *White*	1941	60	0	35,000	11,000	0	0	4	0	2	0	2	0
503			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
504			*x*	0	*x*	*x*	0	0	1	0	1	0	0	0
505			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
506			*x*	0	*x*	*x*	0	0	1	0	1	0	0	0
507	New Haven, *White*	1941	210	0	299,000	127,000	0	0	21	2	0	0	21	0
508			*x*	0	*x*	*x*	0	0	4	0	0	0	4	0
509			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
510			*x*	0	*x*	*x*	0	0	7	1	0	0	7	0
511			*x*	0	*x*	*x*	0	0	4	1	0	0	4	0
512			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
513									4	0	0	0	4	0
514	Phillipstown, *White*	1939	490	0	330,000	205,000	0	0	39	28	0	0	39	0
515			*x*	0	*x*	*x*	0	0	2	1	0	0	2	0
516			*x*	0	*x*	*x*	0	0	2	2	0	0	2	0
517			*x*	0	*x*	*x*	0	0	2	2	0	0	2	0
518			*x*	0	*x*	*x*	0	0	23	22	0	0	23	0
519			*x*	0	*x*	*x*	0	0	2	0	0	0	2	0
520			*x*	0	*x*	*x*	0	0	3	0	0	0	3	0
521			*x*	0	*x*	*x*	0	0	4	0	0	0	4	0
522									1	1	0	0	1	0
523	Stokes, *White*	1939	640	0	670,000	414,000	0	0	28	12	0	0	27	0
524			*x*	0	*x*	*x*	0	0						
525			*x*	0	*x*	*x*	0	0	7	4	0	0	7	0
526			*x*	0	*x*	*x*	0	0	7	6	0	0	7	0
527			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
528			*x*	0	*x*	*x*	0	0	12	0	0	0	11	0
529									1	1	0	0	1	0
530	Storms, *White*	1939	1,510	0	3,676,000	729,000	0	0	156	1	4	0	152	0
531			*x*	0	*x*	*x*	0	0	152	1	4	0	148	0
532			*x*	0	*x*	*x*	0	0	1	0	0	0	1	0
533			*x*	0	*x*	*x*	0	0	3	0	0	0	3	0
534	Roland, *White, Gallatin*	1940	1,820	0	2,983,000	1,887,000	0	0	141	49	6	0	135	0
535			*x*	0	*x*	*x*	0	0	68	25	4	0	64	0
536			*x*	0	*x*	*x*	0	0	4	1	0	0	4	0
537			*x*	0	*x*	*x*	0	0	5	1	1	0	4	0
538			*x*	0	*x*	*x*	0	0						
539			*x*	0	*x*	*x*	0	0	15	8	1	0	14	0
540			*x*	0	*x*	*x*	0	0	17	6	0	0	17	0
541			*x*	0	*x*	*x*	0	0	1	1	0	0	1	0
542									31	7	0	0	31	0
543	Mill Shoals, *White, Hamilton*	1939	1,090	0	2,564,000	906,000	0	0	109	16	0	0	109	0
544			*x*	0	*x*	*x*	0	0	87	14	0	0	87	0
545			*x*	0	*x*	*x*	0	0	19	2	0	0	19	0
546									3	0	0	0	3	0
547	Total fields after Jan. 1, 1937[37]		119,730	1,700	487,362,000	101,837,000	4,291	1,472	12,032[38]	1,133[38]	173	94	11,404	56
548	Total for Illinois[37]		218,750	17,535	939,648,000	106,590,000	6,692	1,485	32,794[38]	1,179[38]	358	324	24,275	64

[37] Total from U. S. Bureau of Mines monthly reports. Includes oil marketed in addition to that shown above.

[38] Includes six small capped gas wells not shown above.

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure,[4] Lb. per Sq. In.		Repressuring Operation	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells							Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average[5]	Sulphur, Per Cent					Top Prod. Zone	Bottoms Prod. Wells				
493	0	18	*x*	*x*		37.6	0.40	Waltersburg	MisU	S	Por	2,156	2,197	20			
494	0	27	*x*	*x*		36.0	0.19	Tar Springs	MisU	S	Por	2,225	2,296	15			
495	0	86	*x*	*x*		39.0	*x*	Cypress	MisU	S	Por	2,561	2,605	25			
496	0	11	*x*	*x*		38.0	*x*	Paint Creek Stray	MisU	S	Por	2,659	2,679	20			
497	0	124	*x*	*x*		36.0	0.24	Bethel	MisU	S	Por	2,684	2,751	25			
498	0	162	*x*	*x*		39.0	*x*	Aux Vases	MisU	S	Por	2,820	2,840	10			
499	0	2	*x*	*x*		*x*	*x*	Rosiclare	MisL	S	Por	2,906	2,920	15			
500	0	98	*x*	*x*		39.2	0.20	McClosky	MisL	L	Por	2,920	2,930	8			
501	0	169						[27]									
502	0	2													A	MisL	3,059
503	0	1	*x*	*x*		*x*	*x*	Waltersburg	MisU	S	Por	2,262	2,282	20			
504	0	0	*x*	*x*		*x*	*x*	Tar Springs	MisU	S	Por	2,355	2,373	16			
505	0	1	*x*	*x*		*x*	*x*	Bethel	MisU	S	Por	2,820	2,830	10			
506	0	0	*x*	*x*		38.0	*x*	McClosky	MisL	L	Por	3,011	3,020	8			
507	0	21													A	MisL	2,900
508	0	4	*x*	*x*		36.4	0.27	Tar Springs	MisU	S	Por	2,115	2,125	10			
509	0	1	*x*	*x*		38.0	*x*	Hardinsburg	MisU	S	Por	2,246	2,251	5			
510	0	7	*x*	*x*		38.0	*x*	Cypress	MisU	S	Por	2,436	2,448	12			
511	0	4	*x*	*x*		39.0	*x*	Aux Vases	MisU	S	Por	2,717	2,732	15			
512	0	1	*x*	*x*		38.0	*x*	McClosky	MisL	L	Por	2,845	2,850	5			
513	0	4						[27]									
514	0	39													A	Dev	5,349
515	0	2	*x*	*x*		*x*	*x*	Degonia	MisU	S	Por	1,997	2,007	10			
516	0	2	*x*	700±		36.0	*x*	Clore	MisU	S	Por	2,019	2,027	8			
517	0	2	*x*	700±		36.0	*x*	Palestine	MisU	S	Por	2,052	2,060	8			
518	0	23	*x*	800±		36.0	*x*	Tar Springs	MisU	S	Por	2,293	2,320	30			
519	0	2	*x*	*x*		39.4	*x*	Aux Vases	MisU	S	Por	2,942	2,964	8			
520	0	3	*x*	*x*		*x*	*x*	Rosiclare	MisU	S	Por	2,955	2,967	10			
521	0	4	*x*	*x*		38.2	0.21	McClosky	MisL	S	Por	2,994	3,004	10			
522	0	1						[27]									
523	0	27													A	MisL	3,150
524			*x*	*x*		*x*	*x*	Tar Springs	MisU	S	Por	2,270	2,285	15			
525	0	7	*x*	*x*		*x*	*x*	Paint Creek Stray	MisU	S	Por	2,760	2,805	27			
526	0	7	*x*	*x*		*x*	*x*	Bethel	MisU	S	Por	2,813	2,827	8			
527	0	1	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	2,890	2,904	14			
528	0	11	*x*	*x*		35.8	0.26	McClosky	MisL	L	Por	3,077	3,124	12			
529	0	1						[27]									
530	0	152													A	MisL	3,082
531	0	148	*x*	*x*		32.1	0.28	Waltersburg	MisU	S	Por	2,234	2,285	18			
532	0	1	*x*	*x*		*x*	*x*	Cypress	MisU	S	Por	2,656	2,685	10			
533	0	3	*x*	*x*		*x*	*x*	Paint Creek Stray	MisU	S	Por	2,807	2,832	14			
534	0	135													A	Dev	5,225
535	0	64	*x*	*x*		31.7	0.25	Waltersburg	MisU	S	Por	2,159	2,174	15			
536	0	4	*x*	*x*		32.0	*x*	Tar Springs	MisU	S	Por	2,231	2,243	12			
537	0	4	*x*	*x*		*x*	*x*	Cypress	MisU	S	Por	2,551	2,568	17			
538			*x*	*x*		*x*	*x*	Paint Creek Stray[28]	MisU	S	Por	2,751	2,763	12			
539	0	14	*x*	*x*		39.0	*x*	Bethel	MisU	S	Por	2,724	2,741	17			
540	0	17	*x*	*x*		*x*	*x*	Aux Vases	MisU	S	Por	2,880	2,898	18			
541	0	1	*x*	*x*		*x*	*x*	McClosky	MisL	S	Por	2,997	3,007	10			
542	0	31						[27]									
543	0	109													A	MisL	3,442
544	0	87	*x*	*x*		39.8	0.14	Aux Vases	MisU	S	Por	3,221	3,241	20			
545	0	19	*x*	*x*		38.0	0.16	McClosky	MisL	L	Por	3,316	3,391	14			
546	0	3						[27]									
547	279	11,125															
548	279	23,996															

TABLE 2.—*Discovery Wells of New Fields in Illinois in 1942*

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.[d]	Date of Completion of Discovery Well	Number of Wells Producing in Field Jan. 5, 1943
1	Akin	Franklin	Seaboard Oil, U. S. Coal & Coke Co. No. 1	C SW SE 14-6S-4E	2,860	2,839	Cypress ss.	113 + 85	3-24-42	3
2	Albion North	Edwards	Taylor Drilling, Odle No. 1	S SE SW 30-1S-11E	3,261	3,054	Aux Vases ss.	19	3-31-42	1
3	Amity	Richland	Boles Bros., W. C. Petty No. 1	NE SE NE 10-4N-14W	2,997	2,961	McClosky ls.	80 + 54	9-29-42	1
4	Barnhill East[a]	Wayne	New Penn Dev. Corp., J. L. Wagner No. 1	NW SW NE 30-2S-9E	3,441	3,432	McClosky ls.	20	3-7-39	4
5	Bartelso South	Clinton	J. F. Ashoff, Jr., Huelsmann No. 1	SE NE NE 20-1N-3W	2,478	2,463	Devonian ls.	100	12-8-42	1
6	Beaver Creek	Bond	W. C. McBride, Inc., V. Jacobs No. 1	SE SW NW 31-4N-2W	2,526	1,116	Bethel ss.	24 + 28	6-23-42	2
7	Bible Grove	Clay	Cameron Bros., Landwehr No. 1	NW NW NE 8-5N-7E	2,825	2,810	McClosky ls.	695	3-24-42	32
8	Bible Grove South	Clay	Kingwood et al., J. E. Essen No. 1	NW NW SE 20-5N-7E	2,929	2,733	Aux Vases ss.	64 + 6	9-1-42	1
9	Blairsville	Hamilton	The Texas, S. Minton No. 1	E SE NE 20-4S-7E	3,531	3,294	Aux Vases ss.	123	8-25-42	10
10	Carmi North	White	Seaboard Oil, Gates No. 1	SW NW SW 3-5S-9E	3,240	3,228	Aux Vases ss.	62 + 38	3-24-42	3
11	Cisne North	Wayne	Shell Oil, Rutger No. 1	E NE NE 17-1N-7E	3,237	3,170	McClosky ls.	35 + 33	9-1-42	2
12	Coil	Wayne	First Nat. Petr. Trust, Ellis No. 1	C SW NE 18-1S-5E	2,940	2,918	Aux Vases ss.	450 + 25	3-31-42	13
13	Coil West	Jefferson	Gulf Refining, Bradford No. 1	NW SE SW 14-1S-4E	2,981	2,794; 2,844	Levias ls.; McClosky ls.	15 + 30	10-13-42	1
14	Concord	White	Minerva Oil, Ramsey No. 1	N SW NE 33-6S-10E	2,917	2,904	Aux Vases ss.	28 + 4	3-17-42	1
15	Covington	Wayne	Deep Rock Oil, Blackburn No. 1	C NW NE 30-1S-7E	3,290	3,238	McClosky ls.	871	6-30-42	32
16	Dubois West	Washington	Gulf Refining, Leffner No. 1	NW NE NW 13-3S-2W	1,685	1,346	Bethel ss.	22 + 33	7-7-42	1
17	Dundas East	Richland	Helmerich & Payne, Stiff Heirs No. 1	SE NE NE 35-5N-10E	3,011	2,999	McClosky ls.	212	7-14-42	11
18	Ellery North	Edwards	Stanolind Oil & Gas, Broster No. 1	SE SE NE 7-2S-10E	3,496	3,418	McClosky ls.	35 + 70	11-10-42	1
19	Fairfield	Wayne	Robinson & Continental, Osborn No. 1	C W NE SW 17-2S-8E	3,389	3,236	Aux Vases ss.	16 + 77	9-29-42	1
20	Friendsville	Wabash	Skiles et al., Wheatly No. 1	E NE SE 3-1S-13W	2,477	2,464	Bethel ss.	35	9-22-42	6
21	Geff West	Wayne	V. A. Thompson, Whitlock No. 1	W SW NW 9-1S-7E	3,320	3,129	Aux Vases ss.	100	9-15-42	2
22	Ingraham[b]	Clay	Nat. Petroleum, Hinterscher No. 1	NW SE SE 10-4N-8E	3,139	3,098	McClosky ls.	5 + 28	6-23-42	0
23	Inman West	Gallatin	B. Martin, Bahl No. 1	SE SE NW 15-8S-9E	2,493	2,482	Cypress ss.	75	5-19-42	5
24	Johnsonville South	Wayne	N. V. Duncan, Anderson, Rogers No. 1	C NE NE 14-1S-6E	3,229	3,212	McClosky ls.	17 + 65	5-26-42	2
25	Johnsonville West[b]	Wayne	Bell Bros., Jones No. 1	W NE SE 24-1N-5E	3,113	3,107	McClosky ls.	8	3-10-42	0
26	Kell	Jefferson	Deaton & Bears, Howard No. 1	NE NE NW 5-1S-3E	2,627	2,625	McClosky ls.	192	4-21-42	1
27	Kenner	Clay	L & W Drilling, Sanders, Thompson No. 1	N NW SE 30-3N-6E	2,715	2,661	Bethel ss.	25 + 20	5-26-42	1
28	King	Jefferson	Lewis Prod., State Game Preserve No. 1	SW SW SE 21-3S-3E	2,762	2,740	Aux Vases ss.	153 + 15	6-23-42	5
29	Markham City	Jefferson	Lario Oil & Gas, Starr Bros. No. 1	N SW SW 1-3S-4E	3,214	3,077; 3,122	Levias ls.; McClosky ls.	190 + 90	8-4-42	12
30	Mt. Olive	Montgomery	W. R. Holmes, Niemann No. 1	NW SE SW 29-8N-5W	602	600	Pennsylvanian ss.	45	12-15-42	1
31	New Bellair	Crawford	Krohn, Wiman No. 1	N NE SE 19-8N-13W	1,380	1,169	Pennsylvanian ss.	55 + 75	3-10-42	2
32	Plainview	Macoupin	Whipple, Rhoades No. 1	NW SE SW 35-9N-8W	421	400	Pennsylvanian ss.	10 + 10	1-27-42	1
33	St. Jacob	Madison	M. D. Bryant, H. Meyer No. 1	SW NE SE 16-3N-6W	2,354	2,278	"Trenton" ls.	118	6-2-42	23
34	Sailor Springs South[c]	Clay	J. H. Jones, Neeley No. 1	NE NW NE 11-3N-7E	2,958	2,940	McClosky ls.	508	6-2-42	4
35	Samsville[b]	Edwards	Menefee, McDowell No. 2	SW SE NE 31-1N-11E	2,437	2,403	Waltersburg ss.	20 + 100	1-20-42	0
36	Sesser	Franklin	I. W. Taylor, Old Ben Coal No. 1	E NW NE 19-5S-2E	2,716	2,701	Aux Vases ss.	132	6-2-42	3
37	Sims North	Wayne	The Texas, Talbert No. 2	S SW SE 17-1S-6E	3,209	3,183	McClosky ls.	303	1-6-42	6
38	Tamaroa	Perry	Harsh, Newborn No. 1	SE SE NW 22-4S-1W	1,150	1,127	Cypress ss.	16	3-24-42	3
39	Toliver	Clay	Big Chief Drilling, Barbee No. 1	SW SW SE 35-5N-6E	2,887	2,790	McClosky ls.	216	9-15-42	1
40	Valier	Franklin	Menhall, Valier Coal No. 2	NE NE SE 7-6S-2E	2,725	2,713	McClosky ls.	15 + 24	5-26-42	1

[a] Wells in secs. 29 and 30, T. 2 S., R. 9 E., Wayne County, formerly included in Goldengate pool assigned name Barnhill East 11/17/42.
[b] Abandoned 1942.
[c] This pool was extended and is now (12/31/42) included with Sailor Springs pool.
[d] Oil and water.

TABLE 3.—*Extensions to Pools in Illinois in 1942*

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.	Date of Completion
1	Bible Grove	Clay	Illinois Producers, Veith No. 1	SE SW NE 5-5N-7E	2,837	2,808	McClosky ls.	66	6-2-42
2	Bone Gap	Edwards	C. F. Steele, C. Couch No. 1	SW frac. 6-1S-11E	3,261	3,254	McClosky ls.	10+75[b]	6-9-42
3	Bonpas West	Richland	Bonpas Development, Woods No. 2	W SW SE 21-2N-14W	3,097	3,090	McClosky ls.	1,086	2-17-42
4	Boyleston	Wayne	H. H. Weinert, Suycott Commun. No. 1	E NE NE 11-2S-7E	3,330	3,318	McClosky ls.	15 + 200	6-23-42
5	Boyleston	Wayne	Pure Oil, Reynolds No. 1	C SE NW 25-1S-7E	3,494	3,346	McClosky ls.	26 + 6	7-7-42
6	Centerville East	White	Sun Oil, Hertlein No. 1	S SE NW 13-4S-9E	3,264	3,259	McClosky ls.	90	4-7-42
7	Clay City Consolidated	Wayne	Pure Oil, Webster No. 1	C SW NW 14-1N-8E	3,080	3,065	McClosky ls.	260	10-20-42
8	Coil	Wayne	W. C. McBride, Youngblood-Gregory No. 1	C SW SE 19-1S-5E	2,893	2,860	Aux Vases ss.	221	9-15-42
9	Cooks Mills	Coles	Baker, Moore No. 1	SE SW NE 34-14N-7E	1,872	1,806	Aux Vases ss.	10	7-21-42
10	Dix	Marion	Braniger et al., Hatfield No. 1	C SW SE 28-1N-2E	2,109	2,101	Rosiclare ss.	90	9-8-42
11	Dundas East	Jasper	Helmerich & Payne et al., Stiff No. 1	SE NW SE 23-5N-10E	3,065	2,940	Levias ls.	316 + 300	10-6-42
12	Flora	Clay	Kingwood Oil, Gatewood No. 1	W NE NE 23-3N-6E	3,074	2,983	McClosky ls.	205 + 9	1-5-43
13	Friendsville	Wabash	W. E. Bailor, R. R. Liddle No. 3	NW SW SW 26-1N-13W	1,771	1,759	Biehl ss.	50 + 20	12-22-42
14	Geff	Wayne	Deep Rock Oil, St. Louis Bank No. 1	C NW SE 7-1S-8E	3,319	3,182	McClosky ls.	270 + 14	1-5-43
15	Geff	Wayne	Pure Oil, G. W. Pike No. 1	C NW NW 13-1S-7E	3,212	3,065	Aux Vases ss.	237	7-28-42
16	Goldengate	Wayne	New Penn Development, Harris No. 1	W NW NE 28-2S-9E	3,311	3,305	Rosiclare ss.	201	4-14-42
17	Herald	White	Carter Oil, E. A. Marlin No. 1	C SW NW 35-6S-9E	2,798	2,792	Bethel ss.	72 + 58	3-10-42
18	Herald	White	Sinclair-Wyoming Oil, E. O. Porter No. 1	SW NW NE 17-7S-9E	3,173	2,841	Bethel ss.	25 + 30	11-10-42
19	Inman East	Gallatin	Cherry & Kidd, Kerwin No. 1	NE NE SW 11-8S-10E	1,851	1,840	Palestine ss.	180 + 54	9-29-42
20	Inman North	Gallatin	Aetna Oil, Foster No. 1	SE SE NE 10-8S-9E	3,060	2,816	Aux Vases ss.	12 + 2	8-25-42
21	Iola	Clay	H. Luttrell, Reed Heirs No. 1	SE NW NE 15-5N-5E	2,306	2,292	Bethel ss.	82	11-24-42
22	Johnsonville South	Wayne	Shell Oil, Montgomery No. 1	C NW SW 14-1S-6E	3,237	3,032	Aux Vases ss.	19 + 8	8-25-42
23	King	Jefferson	Oil Carriers, Inc., Mace No. 1	C NE SE 33-3S-3E	2,848	2,771; 2,823	Levias and McClosky ls.	103	9-15-42
24	King	Jefferson	Nash Redwine, Willmore et al. No. 1	SW NW SW 27-3S-3E	2,812	2,740	Aux Vases ss.	20	10-13-42
25	Lancaster	Wabash	Hayes Drilling, Neikirk Heirs No. 1	S NW NW 9-1N-13W	2,765	2,717	McClosky ls.	40 + 200	8-18-42
26	Markham City	Jefferson	Ohio Oil, Lingle No. 1	N SE SW 36-2S-4E	3,087	3,064	McClosky ls.	513	9-15-42
27	Lawrence South[a]	Lawrence	W. R. White, Hershey No. 1	SE SW SE 27-2N-12W	2,023	2,014	Bethel ss.	126	5-5-42
28	Mason South	Effingham	Luttrell, See No. 1	NW NW NE 34-6N-5E	2,309	2,296	Bethel ss.	84 + 74	7-14-42
29	Maunie North	White	Dawson et al., Clark No. 1	NW SW NE 36-5S-10E	3,094	3,048	McClosky ls.	23 + 13	2-10-42
30	Maunie South	White	Magnolia Petroleum, Pearce Trust No. 1	NE NW SW 35-6S-10E	3,028	2,878	Levias ls.	90	6-16-42
31	Mayberry	Wayne	H. H. Weinert, Thomason Commun. No. 1	N SW SE 32-2S-6E	3,379	3,373	McClosky ls.	40	11-17-42
32	Mt. Erie	Wayne	Pure Oil, Marvel No. 1	C SE NW 26-1N-8E	3,145	2,933	Aux Vases ss.	92	7-7-42
33	Mt. Erie	Wayne	Pure Oil, Allen No. 1	C SE SE 11-1S-8E	3,215	3,068	Rosiclare ss.	9 + 22	9-8-42
34	Mt. Erie South	Wayne	H. H. Weinert, Crews No. 1	S SE SE 28-1S-8E	3,380	3,255	Rosiclare ss.	20 + 20	7-28-42
35	Noble	Richland	Pure Oil, W. G. Murvin "B" No. 1	C NW NW 27-4N-9E	2,710	2,627	Cypress ss.	165	4-14-42
36	Noble	Richland	Pure Oil, Berger Cons. No. 1	SE SE SW 26-4N-9E	2,588	2,547	Weiler ss.	41 + 7	12-15-42
37	Roland	White	Sinclair-Wyoming Oil, Cobbel No. 1	SW SW SW 36-6S-8E	3,158	2,836; 2,955; 3,154	Bethel ss.; Aux Vases ss.; McClosky ls.	159	7-7-42
38	Rural Hill	Hamilton	D. Ring, Craddock No. 1	NE SE NW 22-6S-5E	3,225	3,189	Aux Vases ss.	180 + 14	1-6-42
39	Rural Hill	Hamilton	D. Ring, Johnson No. 1	C NW SE 21-6S-5E	3,257	3,170	Aux Vases ss.	11 + 43	3-31-42
40	Rural Hill	Hamilton	Ohio Oil, M. C. Moore No. 1	NE SE NW 35-6S-5E	3,315	3,296	Aux Vases ss.	146 + 26	7-28-42
41	St. Jacob	Madison	Obering, Buchmann No. 1	SW NW SE 27-3N-6W	2,357	2,209	"Trenton" ls.	147	9-1-42
42	Sailor Springs	Clay	W. C. McBride, W. F. Moench No. 1	SE NE NW 10-3N-7E	2,605	2,592	Weiler ss.	71 + 4	10-13-42
43	Salem	Marion	Big Chief Drilling, Boles No. 1	W SW NW 15-1N-2E	2,085	2,061	Rosiclare ss.	48	5-5-42
44	Sesser	Franklin	J. W. Menhall, Old Ben Coal No. 1	NW NE NW 25-5S-1E	2,882	2,690	Aux Vases ss.	50	6-9-42
45	Sesser	Franklin	J. Darnell, Old Ben Coal No. 1	SE SE NE 20-5S-2E	2,715	2,705	Aux Vases ss.	32 + 11	6-16-42
46	Walpole	Hamilton	Nash Redwine, L. Irvin No. 1	E SE NW 35-6S-6E	3,149	3,134	Aux Vases ss.	311	10-13-42
47	West Frankfort	Franklin	E. S. Adkins, Orient "B" No. 1	SE SE SW 12-7S-2E	2,975	2,698	Aux Vases ss.	15	8-25-42
48	West Frankfort	Franklin	E. S. Adkins, Peabody Coal No. 1	NW NW SW 18-7S-3E	2,055	2,037	Tar Springs ss.	108	12-8-42

[a] Included (11-16-42) with Allendale.
[b] Oil + water.

TABLE 4.—*Discovery Wells of Additional Producing Zones in Pools in Illinois in 1942*

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.	Date of Completion
1	Aden	Wayne	The Texas, H. Silverman No. 5	16-3S-7E	3,340	3,331	McClosky ls.	141	10-20-42
2	Alma	Marion	The Texas, J. Mazanek No. 1	36-4N-2E	1,939	1,930	Bethel ss.	15 + 3[b]	1-20-42
3	Benton North	Franklin	A. W. Torbett, Isaacs No. 1-A	1-6S-2E	2,626	2,600	Paint Creek ss.	30 + 25	3-24-42
4	Bible Grove	Clay	The Texas, W. Landwehr No. 1	8-5N-7E	2,501	2,490	Cypress ss.	132	4-28-42
5	Blairsville	Hamilton	The Texas, Minton No. 5	20-4S-7E	3,458	3,440	McClosky ls.	2,128	1-5-43
6	Boos North	Jasper	Pure, Swick Cons. "A" No. 1	20-6N-10E	2,858	2,807	Rosiclare ss.	748	11-3-42
7	Boulder	Clinton	E. F. Jones, Harrison No. 2	2-2N-2W	2,670	2,584	Devonian ls.	341 + 38	10-6-42
8	Boyleston	Wayne	Gulf Ref., P. Carter No. 1	2-2S-7E	3,236	3,214	Levias ls.	19 + 1	12-1-42
9	Centerville E.	White	Sun Oil, G. Spencer No. 1	8-4S-10E	2,976	2,960	Bethel ss.	64	6-16-42
10	Coil	Wayne	W. C. McBride, S. Gregory No. 1	30-1S-5E	3,056	2,971	McClosky ls.	4 + 11	12-1-42
11	Covington	Wayne	Gulf Ref., Blackburn-Thomas No. 3	19-1S-7E	3,240	3,219	Rosiclare ss.	151	8-25-42
12	Covington	Wayne	Kewanee O. & G. Co., Beck et al. No. 1	29-1S-7E	3,225	3,209	Levias ls.	139	7-21-42
13	Covington	Wayne	Pure, L. C. Finley No. 1	25-1S-6E	3,153	3,115	Aux Vases ss.	10 + 16	9-1-42
14	Dale-Hoodville	Hamilton	Magnolia Petr., Betts et al. No. 1	11-6S-6E	3,163	3,150	Levias ls.	32 + 6	4-21-42
15	Friendsville	Wabash	Skiles, Smalley No. 2	3-1S-13W	2,325	2,289	Cypress ss.	176	11-17-42
16	Geff	Wayne	Pure Oil, G. W. Pike No. 1	13-1S-7E	3,147	3,065	Aux Vases ss.	237	7-28-42
17	Grayville	White	Skelly Oil, S. Fearn No. 1	19-3S-14W	1,842	1,836	Biehl ss.	12 + 30	5-26-42
18	Inman East	Gallatin	Cherry & Kidd, Kerwin No. 1	11-8S-10E	1,851	1,840	Palestine ss.	180 + 54	9-29-42
19	Inman East	Gallatin	Cherry & Kidd, Kerwin No. 5	11-8S-10E	2,057	1,725	Clore ss.	177 + 15	11-3-42
20	Inman East	Gallatin	Skelly Oil, Egyptian T. & T. No. 1	21-8S-10E	2,002	1,980	Waltersburg ss.	210 + 36	6-23-42
21	Iola	Clay	H. Luttrell, Reed Heirs No. 1	15-5N-5E	2,306	2,292	Bethel ss.	82	11-24-42
22	Irvington	Washington	Gulf, Brink No. 4	14-1S-1W	1,389	1,386	Weiler ss.	14	1-5-43
23	King	Jefferson	Oil Carriers Inc., Mace No. 1	33-3S-3E	2,848	2,771	Levias ls.	103	9-15-42
24	King	Jefferson	Oil Carriers Inc., Mace No. 1	33-3S-3E	2,848	2,823	McClosky ls.		
25	Lawrence South[a]	Lawrence	W. R. White, A. Hershey No. 1	27-2N-12W	2,023	2,014	Bethel ss.	126	5-5-42
26	Maunie	White	McElvain et al., Poole-Parr No. 3	13-6S-10E	2,855	2,843	Aux Vases ss.	185	7-14-42
27	Maunie	White	McElvain et al., Poole-Parr No. 6-C	13-6S-10E	2,203	2,190	Tar Springs ss.	192	9-8-42
28	Maunie	White	H. K. Riddle, E. P. Hubele No. 1	7-6S-11E	1,335	1,315	Pennsylvanian ss.	58	5-12-42
29	Maunie South	White	B. Lambert, Sisson-Higgins No. 1	24-6S-10E	1,925	1,904	Degonia ss.	19	6-16-42
30	Mt. Erie	Wayne	Jablonski & Duncan, Garrison No. 1	35-1N-8E	2,988	2,973	Aux Vases ss.	180	9-8-42
31	Mt. Erie South	Wayne	H. H. Weinert, J. Crews No. 1	28-1S-8E	3,380	3,255	Rosiclare ss.	20 + 20	7-28-42
32	Parkersburg	Edwards	Magnolia Petr., C. C. Brake No. 1	31-2N-14W	2,970	2,953	Paint Creek ss.	47	6-2-42
33	Parkersburg	Edwards	Sinclair-Wyoming, A. Bierhaus No. 1	6-1N-14W	2,870	2,832	Weiler ss.	23	7-28-42
34	Phillipstown	White	Jarvis Bros., K. & E. Spencer No. 1	31-4S-11E	2,034	2,019	Clore ss.	40	7-21-42
35	Phillipstown	White	Jarvis Bros., Spencer No. 2	31-4S-11E	2,059	2,052	Palestine ss.	30 + 70	6-23-42
36	Roaches	Jefferson	E. M. Self, J. German No. 1	16-2S-1E	2,200	2,160	Levias ls.	10 + 50	10-13-42
37	Roland	White	Kingwood-Sinclair, Hale "B" No. 1	1-7S-8E	3,050	2,997	McClosky ls.	203 + 10	7-28-42

[a] Included (11-16-42) with Allendale pool.
[b] Oil + water.

footage of wildcat wells drilled in 1942 was 1,367,291 ft., of which a total of 253,125 ft. was drilled in successful wells.

Subsurface geology and geophysics, largely the reflection seismograph, are still the principal methods used in exploration and development in Illinois. The number of seismograph parties operating throughout the year was as follows: 15 on Jan. 1, 1942; 11 on Apr. 1; 13 on Oct. 1; and 12 on Jan. 1, 1943.

Although the amount of seismograph work done in 1942 seems to have been as great as that in 1941, it is noteworthy that the number of well locations made on the basis of seismograph surveys decreased from 90 in 1941 to 38 in 1942, and of these 28 discovered new pools or extensions in 1941 as compared with 10 in 1942. On the other hand, the number of wildcat locations and successful wildcats found by the use of only geology increased in 1942 as compared with 1941.

DEEP TESTS DURING 1942 (TABLE 7)

Five St. Peter sandstone tests were drilled during 1942 but none was found to be productive. Thirty-one "Trenton" tests were drilled in the state. One of these opened the Madison County St. Jacob pool, which produced 261,000 bbl. of oil from 23 wells by the end of the year. Of the 18 Devonian test drilled one was productive—discovering the Devonian oil pay in the Boulder gas field.

DEVELOPMENT

Most of the new discoveries and development during 1942 took place in White, Wayne, Hamilton, Clay, and Jasper Counties in the southeastern part of the state. In White County 302 wells were drilled, of which 213 were producing wells (Table 8). Field development during the year was principally in the Rural Hill (White County), New Harmony Consolidated (White County), Sims (Wayne County), and Roland (White County) fields.

PROSPECTS FOR 1943

It is anticipated that fewer wells will be drilled in 1943 than in 1942, but reduction probably will be in pool wells rather than in "wildcat" drilling. The abundance of geologic data available from the many wells previously drilled, the large areas yet untested to the deeper formations, and the need for more oil, are factors that should stimulate "wildcat" drilling.

ECONOMIC DATA

On the basis of posted prices, the total value of the oil produced in 1942 was

TABLE 4.—(*Continued*)

	Pool	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.	Date of Completion
38	Rural Hill.......	Hamilton	Gulf, B. W. Johnson No. 1	17-6S-7E	2,755	2,707	Cypress ss.	30	10-27-42
39	Sailor Springs S.[c]	Clay	W. C. McBride, Harrison et al. No. 1	3-3N-7E	2,608	2,597	Weiler ss.	34 + 9	9-15-42
40	Salem...........	Marion	Big Chief Drilling, H. Boles No. 1	15-1N-2E	2,085	2,061	Rosiclare ss.	48	5-5-42
41	Sims............	Wayne	The Texas, H. O. Fuhrer No. 2	28-1S-6E	3,185	3,070	Levias ls.	30	1-20-42
42	Sims North......	Wayne	Pure Oil, W. L. Reed No. 1	17-1S-6E	3,178	3,150	Rosiclare ss.	243	3-17-42
43	Stokes..........	White	Pure, Pyle Cons. No. 2	18-6S-9E	2,915	2,890	Aux Vases ss.	152	12-8-42
44	Walpole.........	Hamilton	The Texas, R. Hall No. 3	27-6S-6E	2,472	2,464	Tar Springs ss.	94 + 4	5-26-42
45	Woodlawn.......	Jefferson	J. B. Jackson, T. Myers No. 4	34-2S-1E	1,829	1,815	Weiler ss.	10 + 3	9-1-42

[c] Included (12-31-42) with Sailor Springs pool.

TABLE 5.—*Completions and Production in Illinois since January* 1, 1936

	Number of Completions[a]	Number of Producing Wells	Production, Thousands of Barrels		
			New Fields[b]	Old Fields[b,c]	Total[d]
1936	93	82			4,445
1937	449	292	2,884	4,542	7,426
1938	2,541	2,010	19,771	4,304	24,075
1939	3,675	2,970	90,908	4,004	94,912
1940	3,829	3,080	142,969	4,678	147,647
1941	3,838	2,925	128,993	5,145	134,138
1942:					
January	272	190	11,176	409	11,585
February	103	64	9,450	374	9,824
March	71	37	9,579	407	9,986
April	95	41	8,650	398	9,048
May	149	85	8,646	396	9,042
June	160	74	8,127	393	8,520
July	223	119	8,077	406	8,483
August	179	92	8,075	373	8,448
September	163	91	7,563	395	7,958
October	246	163	7,731	405	8,136
November	176	111	7,424	377	7,801
December	179	112	7,339	420	7,759
	2,016	1,179	101,837	4,753	106,590

[a] Includes only oil or gas producers and dry holes.
[b] Production figures based on information furnished by oil companies and pipe line companies.
[c] Includes Devonian production at Sandoval and Bartelso.
[d] From the U. S. Bureau of Mines.

approximately $145,315,350. Posted prices for Illinois crude oil in 1942 were $1.37 for the central basin fields, Salem area and Griffin area, and $1.22 per barrel for oil in the old fields.

TABLE 6.—*Wildcat Wells Drilled in Illinois in* 1942
CLASSIFIED ACCORDING TO METHOD OF LOCATION

Method	Number of Wells	Number of Producers	Percentage of Wells Successful
Geology	360	68	19
Seismograph	29	5	17
Seismograph and geology	19	5	26
Total scientific	408	78	19
Nonscientific	90	7	8
Unknown	51	11	20
Total	549	96[a]	17

[a] Includes six small gas producers from which no gas has been marketed and two small oil wells that were not commercial but that may be "edge wells."

In 1942 a total of 5,339,504 ft. of hole was drilled in the state. Of this amount 3,194,564 ft. represents producing wells. With an assumed average cost of $4.00 per foot, the total investment in drilling was $21,358,016, including both producing wells and dry holes. In the 549 (1942) "wildcats," 1,367,291 ft. of hole was drilled. At $4.00 per foot, the drilling cost of these "wildcats" amounted to $5,469,164. The average depth of all wells drilled in the state in 1942 was 2607 ft., as compared with 2480 ft. in 1941.

The average initial production of the oil wells for 1942 was 182 bbl. as against 278 bbl. for 1941.

PIPE LINES

Construction of pipe lines in Illinois in 1942 was limited principally to lines connecting new pools with existing trunk lines, as follows:

Crude Oil

Ashland Oil and Refining Co., Inc.—5 miles 4-in., Sims field northeast to Johnsonville (Sohio) pump station, Wayne County; 9 miles 4-in., Coil field northeast to the Johnsonville station, Wayne County.

Central Pipe Line Co.—3 miles 4-in., Bonpas field to Parkersburg field pump station,

TABLE 7.—*Important Tests in* 1942

	County	Pool or Wildcat	Location	Company and Farm	Total Depth, Ft.	Deepest Formation Tested	Top, Ft.	Remarks	Date Completed
1	Adams.......	Wildcat	26-2S-8W	Ohio Oil, G. Fingerlin No. 1	675	St. Peter	666	Dry	3/3/42
2	Adams.......	Wildcat	35-1S-6W	A. L. Williams, Pieper No. 1	987	"Trenton"	789	Dry	10/6/42
3	Alexander....	Wildcat	4-15S-3W	Whitebread & Kippings, R. W. Menton No. 1	609	"Trenton"	?	Dry	10/6/42
4	Bond........	Wildcat	8-6N-4W	E. J. Hubbert et al., Shideler No. 1	2,051	Devonian	1,910	Dry	2/24/42
5	Bond........	Wildcat	31-7N-4W	Downing & George, Sorento Bank No. 1	2,025	Devonian	1,914	Dry	3/24/42
6	Champaign...	Wildcat	20-20N-8E	Barber & Sievers, Lindsey No. 1	2,054	St. Peter	2,027	Dry	11/10/42
7	Clark........	Wildcat	32-9N-14W	C. R. Craft, W. Finney No. 1	2,691	Devonian	2,504	Dry	6/23/42
8	Clark........	Wildcat	7-10N-11W	Craft et al., Imle No. 1	2,623	Devonian	2,464	Dry	6/23/42
9	Clinton......	Wildcat	19-2N-1W	Texas, C. Zimmerman No. 1	2,970	Devonian	2,835	Dry	8/4/42
10	Clinton......	Wildcat	23-2N-5W	E. J. Ruwaldt, Twiss No. 1	3,044	"Trenton"	2,944	Dry	8/25/42
11	Clinton......	Boulder	2-2N-2W	E. Frank Jones, Harrison No. 2	2,670	Devonian	2,584	341 + 38[a]	10/6/42
12	Clinton......	Wildcat	29-2N-4W	Olson Oil, H. B. Alberternst No. 1	3,250	"Trenton"	3,105	Dry	12/1/42
13	Clinton......	Wildcat	33-3N-1W	Gulf, E. Martin No. 1	2,953	Devonian	2,836	Dry	12/22/42
14	Coles........	Wildcat	26-14N-9E	W. L. Topf, T. D. Basler No. 1	1,054	Devonian	1,050	Dry	8/25/42
15	Crawford....	Crawford main	35-6N-13W	Ohio Oil, C. L. Ducommun No. 28	4,654	St. Peter	4,650	Dry	3/17/42
16	Crawford....	Crawford main	4-6N-13W	W. A. Waymire, W. R. Buck No. 1	2,817	Devonian	2,780	Dry	8/25/42
17	Crawford....	Wildcat	26-8N-13W	G. Moulton, Lamb Unit No. 1	2,842	Devonian	2,796	Dry	9/8/42
18	Edgar.......	Wildcat	14-13N-14W	D. Russell, Whiteside No. 1	1,228	Devonian	1,199	Dry	8/25/42
19	Edgar.......	Wildcat	12-15N-14W	Olson Oil, Morrow No. 1	929	Devonian	897	Dry	9/22/42
20	Fulton.......	Wildcat	28-4N-2E	Lagers & Webb, Clear No. 1	1,165	"Trenton"	976	Dry	1/20/42
21	Fulton.......	Wildcat	19-5N-4E	Bowton et al., P. J. McNally No. 1	1,110	"Trenton"	1,097	Dry	4/28/42
22	Hancock.....	Wildcat	24-4N-7W	W. C. Cain, Tobias No. 1	865	"Trenton"	730	Dry	3/3/42
23	Henderson...	Wildcat	22-11N-5W	C. M. Stotts, Stotts-Richmond No. 1	900	Glenwood	865	Dry	1/5/43
24	Iroquois.....	Wildcat	7-25N-13W	Robinson-Puckett, Inc., Behrens No. 1	935	Silurian	313	Dry	1/6/43
25	Iroquois.....	Wildcat	17-26N-12W	Detrick & Stuart, Lockhart No. 1	1,032	"Trenton"	940	Dry	2/24/42
26	Jefferson.....	Wildcat	8-3S-1E	Magnolia Petroleum, Riddle Bros. No. 1	3,860	Devonian	3,705	Dry	2/3/42
27	Jefferson.....	Wildcat	16-3S-3E	Texas, H. P. Crouch No. 1	4,759	Devonian	4,520	Dry	9/15/42
28	McDonough..	Wildcat	4-4N-4W	J. B. Bushnell, Newland No. 1	535	Maquoketa	535	Dry	2/10/42
29	McDonough..	Wildcat	29-4N-4W	C. B. Talbot, F. W. Powell No. 1	725	"Trenton"	700 Est.	Dry	2/17/42
30	McDonough..	Wildcat	2-4N-4W	D. K. Degenther, E. W. Hagon No. 1	782	"Trenton"	650	Dry	6/16/42
31	McDonough..	Wildcat	30-5N-4W	H. J. Hensley, Bushnell No. 1	851	"Trenton"	750	Dry	7/14/42
32	McLean......	Wildcat	33-24N-5E	J. M. McLaughlin, J. McGowan No. 1	2,261	St. Peter	2,125	Dry	11/3/42
33	Madison.....	Wildcat	33-5N-6W	Alch & Carroll, Rinkel No. 1	2,584	"Trenton"	2,457	Dry	3/10/42
34	Madison.....	Wildcat	16-3N-6W	M. D. Bryant et al., H. Meyer No. 1	2,354	"Trenton"	2,319	118	6/2/42
35	Madison.....	Wildcat	19-3N-6W	J. W. Menhall, Holtgrave No. 1	2,403	"Trenton"	2,379	Dry	9/22/42
36	Madison.....	Wildcat	21-4N-8W	Gulf Oil, Stewart No. 1	2,136	"Trenton"	1,976	Dry	9/8/42
37	Madison.....	Wildcat	28-3N-6W	Oils Inc., Noll No. 1	2,506	"Trenton"	2,481	Dry	11/3/42
38	Madison.....	Wildcat	2-4N-6W	L. Sloan, Kisner No. 1	2,619	"Trenton"	2,517	Dry	11/3/42

[a] Oil + water.

Edwards County; 5 miles 4-in., Lancaster station south to Friendsville field, Wabash County; 3 miles 4-in., Benton North field south to Benton field, Franklin County.

Gulf Pipe Line Co.—2 miles 3-in., Mason field to the Edgewood station, Clay County.

Illinois Pipe Line Co.—18 miles 6-in. and 4-in. combination, Bible Grove field to Montrose Station, Effingham County; 8 miles 8-in. Parkersburg field east to Lancaster Station, Wabash County.

Louden Pipe Line Co.—2 miles 2-in., Kell field northwest to the C. & E. I. R. R. near Kell, Marion County.

Magnolia Pipe Line Co.—3 miles 4-in., Roaches field to Woodlawn field, Jefferson County.

Pure Oil Co.—3 miles 4-in. Sainte Marie field to (Sohio) trunk line, Jasper County; 6 miles 6-in. Johnsonville field to Cisne Station, Wayne County; 8 miles 6-in. loop in Cisne field to Clay City field line, Clay County.

Shell Pipe Line Corp.—3 miles 6-in., Rural Hill field north to Illinois Pipe Line, Hamilton County.

Slater Oil and Grease Co.—3 miles 3-in., King field south to C. and E. I. R. R. at Bonnie, Jefferson County.

Sohio Pipe Line Co.—6 miles 4-in., St. Jacob field north to Magnolia trunk line near Marine, Ill.; 5 miles 2-in., St. James field to St. Paul field, Fayette County; 1 mile 2-in., Dundas East field southeast to the Sohio Pipe Line trunk line, Richland County; 20 miles 4-in. and 6-in., Johnsonville field to Flora pump station (Sohio), Clay County; 6 miles 6-in., Covington pump station to

TABLE 7.—(*Continued*)

	County	Pool or Wildcat	Location	Company and Farm	Total Depth, Ft.	Deepest Formation Tested	Top, Ft.	Remarks	Date Completed
39	Madison	Wildcat	20-4N-7W	Ledbetter & Gardenhire, Holtman No. 1	2,320	"Trenton"	2,207	Dry	11/10/42
40	Madison	Wildcat	7-6N-7W	E. C. Stout et al., Goebel et al., No. 1	2,079	"Trenton"	1,987	Dry	12/15/42
41	Montgomery	Wildcat	29-8N-5W	W. R. Holmes, Niemann No. 1	602	Pennsylvanian	600	15	12/15/42
42	Morgan	Wildcat	25-13N-10W	G. L. Hills et al., J. W. Sharp No. 1	952	Devonian	807	Dry	7/28/42
43	Morgan	Wildcat	29-14N-10W	Allan J. Coe, Robinson No. 1	1,041	Devonian	937	Dry	7/21/42
44	Perry	Wildcat	23-4S-2W	Shell Oil, J. Schubert No. 1	3,014	Devonian	2,853	Dry	3/17/42
45	Perry	Wildcat	1-5S-2W	Texas, W. Malinski No. 1	3,087	Devonian	2,889	Dry	6/9/42
46	Pulaski	Wildcat	9-15S-1E	R. G. Williams et al., W. L. Richey No. 1	3,885	St. Peter	3,872	Dry	7/28/42
47	St. Clair	Wildcat	24-1S-10W	W. Payne, W. Ehlers No. 1	1,097	"Trenton"	983	Dry	6/23/42
48	St. Clair	Wildcat	5-2N-6W	Weinert et al., North No. 1	2,471	"Trenton"	2,440	Dry	9/22/42
49	St. Clair	Wildcat	28-2S-8W	T. R. Kerwin, Harbaugh No. 1	1,396	"Trenton"	1,356	Dry	9/15/42
50	St. Clair	Wildcat	5-1N-8W	Mid-Sun Oil, Schneppe Community No. 1	2,001	"Trenton"	1,930	Dry	10/27/42
51	St. Clair	Wildcat	17-2N-7W	L. L. Benoist, Hobrein No. 1	2,095	"Trenton"	2,021	Dry	11/3/42
52	St. Clair	Wildcat	31-2N-7W	P. S. Pritchard et al., Holiday No. 1	2,039	"Trenton"	1,920	Dry	10/27/42
53	St. Clair	Wildcat	14-1N-6W	Smokey Oil, E. Morris Community No. 1	2,765	"Trenton"	2,672	Dry	1/5/43
54	St. Clair	Wildcat	2-1N-8W	Mid-Sun Oil, Randle No. 1	1,977	"Trenton"	1,875	Dry	12/15/42
55	St. Clair	Wildcat	26-2N-6W	V. J. Nolan, J. D. Schoene No. 1	2,689	"Trenton"	2,648	Dry	1/5/43
56	St. Clair	Wildcat	16-2N-8W	Smokey Oil, A. Kinsella No. 1	2,009	"Trenton"	1,925	Dry	1/5/43
57	Schuyler	Wildcat	25-3N-4W	W. Vette, Prudential Life Ins. No. 1	924	"Trenton"	764	Dry	5/5/42
58	Tazewell	Wildcat	24-25N-3W	R. Bartelmay, Mathis No. 1-A	1,675	"Trenton"	1,672	Dry	3/24/42
59	White	Maunie	7-6S-11E	H. K. Riddle, E. P. Hubele No. 1	1,335	Pennsylvanian	?	58	5/12/42
60	White	Storms	27-6S-9E	Green-Johnston, Aud No. 1	89	Pennsylvanian	?	Dry	11/24/42

Johnsonville pump station, Wayne County; 7 miles 2-in., Bone Gap field south to Albion field, Edwards County; 2 miles 3-in., Barnhill East field south to Sohio trunk line, Wayne County; 12 miles 4-in. Woodlawn field to Dix to Centralia (Sohio) line and 6 miles 6-in. from there to Centralia field to Robinson, Ill. trunk line (Sohio); 1 mile 2-in., Sailor Springs Cons. field to the Sohio trunk line, Clay County; 3 miles 2-in., Friendsville field to Maud field, Wabash County; 2 miles 4-in., Concord field northeast to Sohio trunk line, White County; 5 miles 4-in., Rural Hill field north to Sohio trunk line, Hamilton

TABLE 8.—*Summary of Drilling and Initial Production in Illinois for 1942*

	County	Number of Wells Drilled			Total Initial Production		Footage Drilled[a]	
		Total Completions	Total Producing		Oil, Bbl.	Gas, Millions Cu. Ft.	Total	Producing Wells
			Oil	Gas				
1	Adams	2	0	0	0	0	2,237	0
2	Alexander	1	0	0	0	0	609	0
3	Bond	16	3	1	43	0.50	18,870	4,597
4	Champaign	1	0	0	0	0	577	0
5	Christian	2	0	0	0	0	2,997	0
6	Clark	11	1	0	5	0	13,470	1,568
7	Clay	137	74	0	12,387	0	387,891	201,824
8	Clinton	59	28	0	3,890	0	86,002	37,079
9	Coles	12	1	0	10	0	17,749	1,872
10	Crawford	16	3	0	73	0	31,871	5,122
11	Cumberland	5	0	0	0	0	10,171	0
12	Edgar	3	0	0	0	0	3,016	0
13	Edwards	49	30	0	8,850	0	156,230	95,541
14	Effingham	38	16	0	1,316	0	84,500	35,758
15	Fayette	69	47	0	6,125	0	147,146	103,837
16	Franklin	65	23	0	1,700	0	178,300	57,779
17	Fulton	2	0	0	0	0	2,275	0
18	Gallatin	53	30	1	3,233	2.00	130,315	70,827
19	Hamilton	256	185	0	47,341	0	810,785	581,231
20	Hancock	1	0	0	0	0	865	0
21	Hardin	1	0	0	0	0	1,822	0
22	Henderson	1	0	0	0	0	900	0
23	Iroquois	2	0	0	0	0	1,967	0
24	Jackson	5	0	0	0	0	6,493	0
25	Jasper	101	71	0	18,398	0	289,945	202,763
26	Jefferson	84	32	0	4,524	0	216,626	80,409
27	Johnson	1	0	0	0	0	705	0
28	La Salle	1	0	0	0	0	420	0
29	Lawrence	58	37	5	3,779	5.17	98,799	66,746
30	Livingston	1	0	0	0	0	315	0
31	McDonough	5	1	0	2	0	3,340	447
32	McLean	1	0	0	0	0	2,261	0
33	Macon	1	0	0	0	0	1,333	0
34	Macoupin	20	1	4	10	1.85	9,477	2,577
35	Madison	35	23	0	5,034	0	85,323	54,617
36	Marion	42	13	0	512	0	94,644	21,156
37	Monroe	1	0	0	0	0	242	0
38	Montgomery	4	1	1	45	0.60	2,536	602
39	Morgan	3	0	0	0	0	2,403	0
40	Peoria	1	0	0	0	0	966	0
41	Perry	14	3	0	50	0	22,793	3,422
42	Pulaski	1	0	0	0	0	3,885	0
43	Putnam	1	0	0	0	0	375	0
44	Randolph	2	0	0	0	0	2,707	0
45	Richland	92	49	1	7,231	3.80	271,856	142,205
46	St. Clair	24	5	0	155	0	13,210	3,359
47	Saline	12	0	0	0	0	37,609	0
48	Schuyler	1	0	0	0	0	924	0
49	Shelby	4	0	0	0	0	7,765	0
50	Tazewell	1	0	0	0	0	1,675	0
51	Wabash	95	61	0	6,076	0	220,307	139,938
52	Washington	29	14	0	576	0	43,811	20,724
53	Wayne	297	201	0	52,292	0	955,420	645,581
54	White	302	213	0	27,982	0	830,614	612,983
55	Williamson	7	0	0	0	0	19,160	0
		2,048	1,166	13	211,639	13.92	5,339,504	3,194,564

[a] Includes old wells deepened.

TABLE 9.—*Fields with Wells Producing from More than One Formation*

	Field	County	Total Number of Combination Wells	Number of Wells and Producing Formations[a]
1	Iola	Clay	1	1BA
2	Clay City Consolidated	Clay, Wayne	12	6RM, 1ARM, 1AM, 1CR, 1CB, 2AR
3	Albion	Edwards	5	2BA, 1BM, 2BAM
4	Mason South	Effingham	6	6BA
5	Louden	Effingham, Fayette	191	101CP, 45CB, 14PB, 31CPB
6	Inman East	Gallatin	7	2CW, 1C1T, 2TW, 1PaW, 1PWT
7	Blairsville	Hamilton	1	1ALM
8	Dale-Hoodville Consolidated	Hamilton	45	1CA, 1CM, 1LA, 1CB, 40BA, 1RM
9	Rural Hill	Hamilton	60	20AL, 19ALM, 8LM, 12AM, 1RA
10	King	Jefferson	2	1ALM, 1LM
11	Markham City	Jefferson	1	1LM
12	Salem	Marion	689	470BA, 215MS, 2BAM, 1AM, 1MD
13	Dundas Consolidated	Richland, Jasper	5	1AM, 4RM
14	Keensburg Consolidated	Wabash	14	2BiC, 6BC, 2BA, 2AM, 1CBA, 1CA
15	Maud	Wabash	1	1WM
16	Mt. Carmel	Wabash	11	1RM, 2BiC, 2BiCM, 6CM
17	Irvington	Washington	1	1CB
18	Barnhill	Wayne	2	2RM
19	Boyleston	Wayne	3	2LM, 1RM
20	Covington	Wayne	2	2LM
21	Johnsonville	Wayne	7	5AM, 2AL
22	Mt. Erie	Wayne	1	1RM
23	Sims	Wayne	18	1AL, 4LM, 1RM, 3LAM, 9AM
24	Sims North	Wayne	1	1RM
25	Aden	Wayne, Hamilton	1	1AM
26	Centerville East	White	1	1LT
27	New Haven	White	4	2TC, 2CM
28	Phillipstown	White	1	1CT
29	Stokes	White	1	1TP
30	Roland	White	31	1WP, 1WCP, 1WP, 3BA, 1BAM, 1WCA, 3CB, 9WB, 9WA, 1CBA, 1CA
31	Iron	White	3	1TC, 1TH, 1BM
32	Maunie South	White	3	3PaT
33	New Harmony Consolidated	White	169	5CP, 1TPB, 30PB, 1TB, 7CBM, 7WCBA, 3CBAM, 1TCM, 2WC, 27CB, 28CBA, 2WA, 3TCA, 3TA, 1TCB, 5AM, 13BA, 1WB, 1TM, 1CM, 2WCBAM, 1WCB, 1CPM, 13CA, 2TC, 1CPB, 1BM, 1CPBAM, 1BiCA, 1PA, 1WM, 1WBM, 1RM
34	Mills Shoals	White, Hamilton	3	3AM
			1,303	

[a] Names of sands indicated as follows:

Bi, Biehl
Bu, Buchanan
Pa, Palestine
Cl, Clore
W, Waltersburg

T, Tar Springs
H, Hardinsburg
C, Cypress
P, Paint Creek Stray
B, Bethel

A, Aux Vases
L, Levias
R, Rosiclare
M, McClosky
S, Salem
D, Devonian

TABLE 10.—*Natural Gas Marketed in Illinois in* 1942

Field	County	Where Marketed	Amount Produced and Marketed, M Cu. Ft.
Russellville gas	Lawrence	Illinois, Indiana, Kentucky	1,472,183
Ayers gas	Bond	Greenville, Illinois	13,454
Salem[a]	Marion	Centralia, Salem and Mt. Vernon, Illinois	284,584
Louden[a]	Fayette	Brownstown, St. Elmo, Vandalia, Illinois	703,216
Albion[b]	Edwards	Albion, Illinois	100,000
Total Illinois			2,573,437

[a] Residue gas from natural-gasoline plants.
[b] Used in brick plants until latter shut down 3/31/42.

County; 4 miles 4-in., Walpole field north to Dale-Hoodville Consolidated field, Hamilton County; 3 miles 6-in. loop on Storms to Indiana line.

Sun Oil Co.—2 miles 4-in., Centerville East field west to Centerville Station, White County; 5 miles 4-in., Rural Hill field northeast to Illinois Pipe Line line, Hamilton County.

Texas Pipe Line Co.—4 miles 4-in., 4 miles 6-in., Rural Hill field northeast to pump station and 33 miles 6-in. from there north to Sims field and northeast to Johnsonville pump station, Wayne County; 7 miles 6-in., Blairsville field north to Aden field, Hamilton County.

War Emergency Pipeline—107 miles 24-in., Mississippi River near Thebes, Ill. northeast to the Wabash River at sec. 23, T. 4 S., R. 14 W., White County.

Natural Gas

Illinois Iowa Power Co.—4 miles 6-in., Salem field southwest to Centralia to Mt. Vernon line; 20 miles 4-in., Centralia, Ill. to Mt. Vernon, Ill.; 14 miles 4-in., Monmouth, Ill. to Galesburg, Ill.; 2 miles 4-in., Oglesby, Ill. north to La Salle, Ill.; 2 miles 4-in., La Salle, Ill. west to Peru, Ill.; 2 miles 4-in., Spring Valley, Ill. east to Peru, Ill.; 4 miles 3-in., Peru, Ill. north to trunk line.

Illinois St. Louis Gas Line Co.—9 miles 4-in., Salem field to Centralia, Ill.

Industrial Natural Gas Co.—12 miles 4-in., 8 miles 6-in., Salem field to Mt. Vernon, Ill.

Natural Gas Pipe Line Co. of America.—2 miles 2-in., Geneseo, Ill. southeast to trunk line; 10 miles 6-in., Sterling, Ill. south to trunk line; 10 miles 8-in., Rockford, Ill. southeast to trunk line; 18 miles 4-in., Sycamore, Ill. northwest to trunk line.

Texas Pipe Line Co.—75 miles 6-in., Salem field to Lawrenceville Station, Lawrence County.

Refineries

No new refineries were constructed in Illinois during 1942, but the total daily refinery capacity was increased from 275,450 to 281,100 barrels.

During the year, 33.1 per cent of Illinois crude oil production was sent to refineries in the Central refining district (Illinois, Indiana, Kentucky, Michigan and western Ohio) and to the Appalachian refining district (eastern Ohio, western New York, western Pennsylvania and West Virginia). For December 1942, the runs to stills in the Central and the Appalachian refining districts were 26,967,000 bbl. Of this amount, Illinois production was 28.8 per cent. Stocks of crude petroleum on hand in Illinois on Dec. 31, 1942 were 9,170,000 bbl., as compared with 18,280,000 bbl. on Dec. 31, 1941. Stocks of refined products in the Central and Appalachian refining districts compared with the previous year, according to the U. S. Bureau of Mines, are as follows:

Product	Dec. 31, 1942, Bbl.	Dec. 31, 1941, Bbl.
Gasoline	19,026,000	22,011,000
Gas oil and distillate fuel	6,643,000	4,763,000
Residual fuel oil	3,025,000	4,479,000

Production of Natural Gas

The amount of natural gas produced and marketed in Illinois during 1941 was 2,573,437 M cu. ft. The amount sold from each field is given in Table 10.

Russellville Gas Field.—Five new wells were drilled within proved territory in the Russellville gas field during 1942, bringing the total number of producing wells in the field to 53. Three of these wells produce from the Bridgeport sand and two from the Buchanan sand. To the end of 1942 the productive area of Buchanan sand proved by drilling was 1600 acres, and of the Bridgeport, 270 acres. The initial productions of the wells was of the order of 2,000,000 cu. feet.

Ayers Gas Field.—One well was completed in the Ayers gas field, Bond County, during the year and brought the number of producing wells in that field to 8. The field was discovered in 1922, covers 335 acres and has produced a total of approximately 221,000,000 cu. ft. of gas from the

Bethel sandstone at a depth of about 950 feet.

NATURAL GASOLINE PLANTS

Natural gas accompanying oil production in the Louden field during 1942 is estimated at 8,400,000,000 cu. ft. The average daily production at the end of the year was approximately 20,000,000 cu. ft. The greater part of this gas is processed daily by the Carter Oil Company's two repressuring plants and 6,000,000 cu. ft. of residue gas is injected into the producing sands. Residue gas from the two plants is furnished also to the G. H. and G. Pipe Line Co. for the towns of St. Elmo, Brownstown, and Vandalia, Ill., at the rate of 1,900,000,000 cu. ft. per day. The pipe-line company also receives 50,000 cu. ft. of gas daily from a well in the Louden field, which is producing from a basal Pennsylvanian sandstone.

The production of natural gas in the Salem field for 1942 is estimated at 23,700,000,000 cu. ft. At the end of the year the estimated daily production was 63,000,000 cu. ft. Of this amount 49,800,000 cu. ft. per day is processed by the four natural-gasoline plants in the field. The Texas Company returns approximately 5,000,000 cu. ft. of residue gas daily to the producing sands in its repressuring operations in the Salem field. Residue gas from the Warren Petroleum Company's plant is supplied to the cities of Salem, Centralia, and Mt. Vernon, Illinois. This consumption at the end of the year was approximately 800,000 cu. ft. per day.

Two new natural-gasoline plants were built in Illinois during 1942. The Warren Petroleum Corporation's plant at Crossville began operation in July and the Texas Company's plant near Hoodville began operation in December. A small amount of gas was returned to the producing sands of this field through several input wells during 1942, marking the beginning of a large-scale pressure-maintenance system there.

The Warren Petroleum Corporation's Crossville plant is in the New Harmony Consolidated field, White County. This field made an estimated 8,700,000,000 cu. ft. of gas during 1942. At the end of the year the estimated daily production was 21,000,000 cu. ft. Part of this was processed by the Crossville plant; an average of approximately 1,500,000 cu. ft. of residue gas was returned to the producing sands daily during the latter half of 1942. An estimated 100,000,000 cu. ft. of natural gas produced with the oil in the Albion pool, Edwards County, was marketed to brick-manufacturing plants at Albion, Ill., during the first quarter of 1942. Daily average production for the Albion field for 1942 was approximately 2,000,000 cu. feet.

New oil fields and further extension of the productive acreage of the older oil fields increased the production of natural gas accompanying oil production during 1942. The total gas production for 1942 for the fields discovered after Jan. 1, 1937, is estimated at 84,400,000,000 cu. ft. A large part of this production is burned in flares.

NATURAL GASOLINE AND LIQUEFIED PETROLEUM GASES

Natural gasoline is produced in 40 plants in the old Southeastern field, with a total capacity of approximately 10,000 gal. daily; seven plants, including two in the Louden field, one in the New Harmony Consolidated field and four in the Salem field, have a total capacity of approximately 280,000 gal. daily. According to the U. S. Bureau of Mines,* 66,616,000 gal. of natural gasoline was produced in Illinois in 1942. In January, the amount was 5,582,000 and there was not much fluctuation from this figure throughout the year. The production of liquefied petroleum gases for 1942 amounted to 73,619,000 gal., according to the U. S. Bureau of Mines.

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* G. R. Hopkins, personal communication, February 1943.

In January the amount was 5,325,000 gal. and there was a steady increase to 7,680,000 for December.

SECONDARY RECOVERY

The most important event in secondary recovery in Illinois in 1942 was the inauguration of two water-flooding projects by the Forest Producing Corporation, one in Cumberland County and one in Clark. This company brought to Illinois the wide experience gained in successful operations in Pennsylvania and Oklahoma. Water input began in July 1942 following the drilling of some 34 input wells and 20 oil wells. Later the Pure Oil Co. started three "circle" floods in the "McClosky" in the Clay City area, by converting former oil wells into water-input wells. The Adams Corners Oil Co. continued its successful flooding operations on the Biehl sand in the Allendale field. More than 50 water-input wells are being operated in the state. Two important flooding operations in the Patoka field (Marion County) and in the Colmar-Plymouth field (McDonough County), planned in 1942 were not started until 1943. These projects have aroused great interest among producers throughout the state and the results so far obtained encourage the hope that through this process many fields will have a new lease on life.

The practice of repressuring with gas, air, or a combination of the two, was somewhat extended over that of 1941, the principal companies reporting more than 500 input wells in operation. The skillfully engineered pressure-maintenance operation conducted by the Carter Oil Co. in the Louden field was expanded by the addition of six new input wells. An operation was started at New Harmony covering a large part of the pool. The Warren Petroleum Co. erected a combined gasoline and repressuring plant near Crossville, extracting gasoline and liquefied petroleum gases by pressure and absorption from the casing-head gas. A large part of the residue gas from this plant is being injected into the oil sands. These large operations at Louden, Salem, and New Harmony are doing much to make use of the gas and to conserve the reservoir energy of their respective territories. Repressuring in the old field showed little change, except that new operations were planned which did not begin until 1943.

LEGISLATION AND REGULATION

Federal Conservation Order M-68, which restricted drilling to one well to 40 acres in order to save steel, was in effect during the first eight months of 1942. Order M-68-5 superseded it Aug. 31 and was in effect for the last four months of the year. The latter permitted a well spacing of one well to 10 acres for wells producing from sandstone formations less than 2500 ft. deep and one well to 20 acres for wells producing from sandstone formations 2500 ft. deep or more. The spacing of one well to 40 acres for limestone formations was continued.

Rules and regulations for water-flooding of oil properties and rules and regulations relating to wells to be drilled for oil, gas, coal, or water, the plugging of wells, issuance of permits therefor, prevention of waste, etc., were issued by the Department of Mines and Minerals, Springfield, Ill. during 1942. The former were approved Feb. 20, 1942; the latter were adopted Aug. 26, 1942. The rules and regulations were issued pursuant to Section 6 of the Illinois Act entitled "An Act in Relation to the Conservation of the Oil, Gas, and Coal Resources in this State," which was effective July 29, 1941.

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Oil and Gas Activity in Indiana in 1942

By Ralph E. Esarey* and George V. Cohee†

In Indiana, 349 wells were drilled for oil and gas in the year 1942. Of this number, 125 oil wells and 21 gas wells were successfully completed and 203 were dry holes. Drilling activity declined 37 per cent as compared with that of the year 1941. This reduction was brought about largely by Federal Conservation Order M-68, restricting drilling to one well on 40 acres, in order to save steel. This Order was later supplemented to permit closer spacing of wells drilled to sandstone formations in southwestern Indiana.

Most of the drilling in 1942 was in the southwestern part of the state. Posey County ranked first, with 94 completions and 44 producers; Gibson County, second, with 77 completions and 38 producing oil wells and 2 gas wells. There were 58 drilling operations in the state at the end of the year. During 1942 a total of 589,734 ft. of hole was drilled, of which 231,702 ft. was wildcat footage. The total initial production of the oil wells completed was 9974 bbl. and of the gas wells, 11,148,000 cu. ft. (Table 2).

Of the 349 wells completed, 122 were wildcat wells (Table 3); 26 were completed as oil wells; 17 were extensions to proven fields and 9 discovered new pools. Posey County was foremost in wildcat drilling, with 37 wells completed (Table 6). Thirty-five per cent of the wells drilled in 1942 were wildcat, as compared with 25.5 per cent in 1941. It is anticipated that the percentage of wildcat wells drilled in 1943 will be greater, although the total number of wells drilled in the state will probably be less.

The new discoveries in Indiana in 1942 were, for the most part, one-well pools in the southwestern part—in Posey, Gibson and Spencer Counties (Table 4). Most of the development in pools took place in the Hazelton and Kirksville pools in Gibson County, Mt. Vernon pool in Posey County and the Vernon Heights pool in Vanderburgh County. Deeper production was obtained from the Osage limestone in the Hazelton pool at a depth of 2402 ft., 650 ft. below the productive McClosky limestone. The well had an initial production of 140 barrels. Extensions to 17 pools in the southwestern part of the state were successfully completed (Table 5).

An interesting development during 1942 was new production from the Devonian limestone in the Dodds Bridge pool, Sullivan County. The Ohio Oil Co. deepened one of its wells, which had been producing from a shallow sand, to the Devonian, and it was completed for an initial production of 77 bbl. Five other Devonian producing wells were completed in that area.

Crude-oil production in Indiana in 1942 was 6,609,000 bbl. (Table 1). The Griffin field, Gibson and Posey Counties, which produced approximately 3,550,000 bbl., accounted for more than half of the state's production. The Mt. Vernon and New Harmony fields were next in importance of production, with 684,000 and 523,000 bbl., respectively. The price of crude oil was $1.22 a barrel for the old

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TABLE 1.—*Oil and Gas Production in Indiana*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
1	Cannelburg, *Daviess*	1925	630	50	120,700	18,500
2	Glendale-Hudsonville, *Daviess*	1929	0	1,200	0	0
3	North Glendale, *Daviess*	1941	0	160	0	0
4	Veale, *Daviess*	1926	420	0	*y*	34,400
5	Greensburg, *Decatur*	1893	0	37,000	0	0
6	Columbia, *Gibson*	1941	90	0	3,000	900
7	Fleenor, *Gibson*[1]	1940	20	0	4,500	0
8 9	Francisco, *Gibson*	1929	530	200	189,200	3,200
10 11 12	Hazelton, *Gibson*	1941	760	0	186,600	165,900
13	Johnson, *Gibson*	1941	20	0	4,700	1,200
14	Kirksville, *Gibson*	1941	170	80	41,200	41,200
15	Mt. Carmel, *Gibson*[2]	1941	20	0	5,300	3,800
16	Owensville, *Gibson*[1]	1940	20	0	4,900	300
17	Patoka, *Gibson*	1941	40	0	4,900	3,400
18	Somerville, *Gibson*	1942	20	0	2,200	2,200
19	West Princeton, *Gibson*	1903	1,370	500	1,270,000	2,200
20 21 22 23 24 25	Griffin, *Gibson, Posey*	1938	3,970	0	13,029,300	3,508,800
26 27	Mumford Hills, *Gibson, Posey*	1939	340	0	42,200	10,600
28	Laconia (Harrison), *Harrison*	1910	0	6,600	0	0
29	Trenton, *Jay and many counties*[5]	1886	127,000	650,000	104,748,300	30,300
30 31 32 33	Monroe City, *Knox*	1922	400	0	*y*	1,000
34	Oaktown, *Knox*	1930	40	1,040	60,000	1,600
35	St. Francisville, *Knox*[2]	1942	40	0	400	400
36	St. Thomas, *Knox*	1940	80	0	65,100	9,700
37	Loogootee, *Martin, Daviess*	1900	300	1,900	*y*	*y*
38	Unionville, *Monroe*	1929	0	1,400	0	0
39 40 41	Bristow, *Perry*	1929	150	120	104,100	1,000
42 43 44	Troy-Tell City, *Perry, Spencer*	1928	860	80	279,300	16,500
45 46	Alford, *Pike*[4]	1919	130	960	312,000	2,400
47	Iva, *Pike*	1935	0	160	0	0
48	Spurgeon, *Pike*	1941	20	0	15,200	14,500
49 50	Oakland City, *Pike, Gibson*	1907	2,910	200	*y*	18,100
51 52 53 54	Oatsville-Wheeling, *Pike, Gibson*	1919	1,920	0	*y*	135,200
55 56	Tri County, *Pike, Gibson*	1925	370	80	181,400	9,900
57 58 59	Union-Bowman, *Pike, Gibson*	1916	4,600	500	*y*	154,900

[b] Footnotes for column heads and explanation of symbols are given on page 264.

[1] Abandoned.

[2] Extension from Illinois.

[4] Includes Petersburg field.

[5] Includes Rush gas field.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
				During 1942		End of 1942			Number of Wells						
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[e]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
1	y	0	79	3	1	0	26	0	0	26	x	x		y	y
2	y	157.0	66	0	0	0	0	21			275	y			
3	102.4	102.4	8	4	1	0	0	7			y	y			
4	0	0	81	2	0	0	31	0	0	31	x	x		y	y
5	4,510.8	210.8	399	4	2	0	0	164			275	y			
6	0	0	5	1	0	0	5	0	0	5	x	x		36.0	y
7	0	0	1	0	1	0	0	0	0	0	x			x	x
8 9	1,252.7	4.5	46	0	14	0	15	1	0	15	690	y		33.0	x
10 11 12	0	0	17	14	1	0	17	0	0	17	y y	y y		39.5 y	y y
13	0	0	2	1	0	0	1	0	0	1	x	x		32.0	y
14	0	y	15	12	0	0	13	2	0	13	y	y		35.0	y
15	0	0	1	0	0	0	1	0	0	1	y	y		38.0	y
16	0	0	1	0	1	0	0	0	0	0	x	x		39.5	y
17	0	0	2	0	0	0	2	0	0	2	x	x		40.5	y
18	0	0	2	2	0	0	2	0	0	2	x	x		y	y
19	y	0	151	0	0	0	31	0	0	31	x	x		y	y
20 21 22 23 24 25	0	0	420	20	1	0	408	0	0	408	y	y	PM	38.0	y
26 27	0	0	12	1	0	0	9	0	0	9	y	y		y	y
28	3,900.0	100.0	129	0	2	0	0	32	0	0	175	y			
29	800,000.0	10.4	26,602	4	43	0	200	39	0	200	325	y		36.0	y
30 31 32 33	0	0	15	0	0	0	7	0	0	7	x	x		y	y
34	1,949.3	45.8	80	0	0	0	5	25	0	5	281	y		35.0	y
35	0	0	1	1	0	0	1	0	0	1	y	y		39.5	y
36	0	0	6	1	0	0	5	0	0	5	y	y		y	y
37	y	18.8	59	0	2	0	0	14			x	x		x	x
38	355.5	239.9	18	0	0	0	0	13			250	y			
39 40 41	0	0	45	0	0	0	4	0	0	4	x	x		33.0	y
42 43 44	395.0	y	83	1	4	0	27	2	0	27	x	y		34.0	y
45 46	y	3.2	97	0	0	0	7	20	0	7	x	y		38.0	y
47	y	35.4	5	2	0	0	0	5	0	0	x	x			
48	0	0	2	1	0	0	2	0	0	2	y	y		34.5	y
49 50	y	0	267	0	0	0	35	0	0	35	x	y		28.0	y
51 52 53 54	0	0	256	1	0	0	186	0	0	186	x	y		32.0	y
55 56	y	0	74	0	1	0	13	0	0	13	x	y		34.0	y
57 58 59	y	y	403	0	4	0	275	0	0	275	x	y		35.0	y

TABLE I.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age^e	Character^f	Porosity^g	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure^h	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
1	L. Chester	MisU	S	Por	630	640	10	A	Chester	895
2	Barker	MisU	S	Por	650	660	10	T	St. Louis	1,575
3	Cypress	MisU	S	Por	678	729	x	D	MisL	851
4	McClosky	MisL	Ls	Por	1,161	1,171	10	A	Devonian	2,618
5	Trenton	Ord	Ls	Por	886	907	10	A	Pre-Cambrian	3,055
6	Cypress	MisU	S	Por	1,190	1,232	6	D	MisU	1,536
7	McClosky	MisL	Ls	Por	2,673	2,714	8	D	MisL	2,714
8	Brown	MisU	S	Por	1,340	1,380				
9	McClosky	MisL	Ls	Por	1,600	1,650	25	A	Ordovician	4,006
10	McClosky	MisL	Ls	Por	1,735	1,750	5	A	Silurian	3,450
11	Salem	MisL	Ls	Por	2,085	2,130	5			
12	Osage	MisL	Ls	Por	2,402	2,447	10			
13	Pennsylvanian	Pen	S	Por	1,095	1,105	6	D	MisL	2,802
14	Hardinsburg	MisU	S	Por	1,333	1,352	22	A	MisL	1,810
15	Cypress	MisU	S	Por	1,976	1,988	12	A	MisL	2,355
16	St. Louis	MisL	Ls	Por	2,690	2,697	7	D	MisL	2,703
17	McClosky	MisL	Ls	Por	2,250	2,270	y	D	Ste. Genevieve	2,300
18	Tar Springs	MisU	S	Por	1,117	1,137	20	D	MisU	1,137
19	West Princeton	PenL	S	Por	890	920	y	A	St. Louis	3,905
20	Pennsylvanian	Pen	S	Por	1,250	1,850	15	A	Osage	3,526
21	Waltersburg	MisU	S	Por	2,050	2,070	20			
22	Tar Springs	MisU	S	Por	2,125	2,140	15			
23	Cypress	MisU	S	Por	2,500	2,525	25			
24	Aux Vases	MisU	S	Por	2,750	2,770	20			
25	McClosky	MisL	Ls	Por	2,850	2,860	8			
26	Cypress	MisU	S	Por	2,458	2,475	17			
27	McClosky	MisL	Ls	Por	2,912	2,938	12	D	MisL	3,047
28	New Albany	Dev.	H	Fis	650	680	20	M	Trenton	1,770
29	Trenton	Ord	L, D	Por, Fis	900	1,250	10	A	Pre-Cambrian	3,996
30	Mansfield	Pen	S	Por	880	900	10	M	Salem	1,935
31	Cypress	MisU	S	Por	1,235	1,260	15			
32	Mooretown	MisU	S	Por	1,465	1,475	10			
33	Paoli	MisU	Ls	Por	1,520	1,536	y			
34	Staunton	PenL	S	Por	580 790	610 802	y	ML	Ste. Genevieve	1,592
35	Bethel	MisU	S	Por	1,737	1,772	13	A	MisL	1,936
36	McClosky	MisL	Ls	Por	1,871	1,922	8	D	Ste. Genevieve	2,050
37	Mooretown	MisU	S	Por	532	542	10	A	Trenton	3,025
38	Corniferous	DevM	Ls	Por	800	850	40	AF	Trenton	2,102
39	Tar Springs	MisU	S	Por	280	287	7	ML	Ste. Genevieve	710
40	Cypress	MisU	S	Por	465	485	10			
41	Elwren	MisU	S	Por	503	512	9			
42	Sample	MisU	S	Por	468 714	492 728	y	NMF	MisL	1,708
43	Cypress	MisU	S	Por	747	759	y			
44	Mooretown	MisU	S	Por	805	827	y			
45	Oakland City	MisU	S	Por	630	640	10	A	St. Louis	1,413
46	Brown Sands	MisU	S	Por	1,080 1,130	1,100 1,140	10			
47	Hardinsburg	MisU	S	Por	750	760	8	D	MisL	1,174
48	Cypress	MisU	S	Por	1,143	1,151	8	D	MisU	1,151
49	Oakland City	MisU	S	Por	1,085	1,112	10	A	Paoli	1,444
50	Brown	MisU	S	Por	1,107	1,126	10			
51	Sample	MisU	S	Por	1,250	1,270	y	A	Harrodsburg	2,050
52	Cypress	MisU	S	Por	1,270	1,290	y			
53	Mooretown	MisU	S	Por	1,340	1,360	y			
54	Paoli	MisU	S	Por	1,725	1,740	y			
55	Brazil	PenL	S	Por	315	331	10	A	Ste. Genevieve	1,998
56	Oakland City	MisU	S	Por	1,317	1,335	10			
57	Cypress	MisU	S	Por	945	950	5	A	Salem	2,205
58	Mooretown	MisU	S	Por	1,233	1,250	y			
59	Paoli	MisU	Ls	Por						

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
60 61	Bufkin, *Posey*	1940	150	0	97,400	30,200
62 63 64	Caborn, *Posey*	1940	500	160	351,300	248,800
65	Caborn West, *Posey*	1941	80	0	25,100	12,100
66	College, *Posey*	1940	60	0	75,200	25,900
67	Grafton, *Posey*[1]	1942	20	0	800	800
68	Half Moon, *Posey*	1942	20	0	3,900	3,900
69	Hovey Lake, *Posey*	1942	20	0	1,000	1,000
70	Lamott, *Posey*	1941	40	0	22,500	18,700
71 72	Mt. Vernon, *Posey*	1941	300	0	729,200	668,100
73 74 75	New Harmony, *Posey*	1939	300	0	1,675,900	523,900
76	New Haven, *Posey*[2]	1942	20	0	6,900	6,900
77	Point, *Posey*	1942	20	0	20,300	20,300
78	Prairie, *Posey*	1942	20	0	7,400	7,400
79	Rapture, *Posey*[1]	1941	20	0	600	0
80	Ridge, *Posey*	1942	20	0	1,000	1,000
81	St. Wendells, *Posey*	1934	240	0	*y*	6,200
82	Stooker, *Posey*	1942	40	0	15,500	15,500
83	Welborn, *Posey*	1941	20	0	9,500	5,500
84 85	Heusler, *Posey, Vanderburgh*	1938	30	0	880,700	234,900
86	Unionport, *Randolph*	1939[3]	0	960	0	0
87 88	Enterprise, *Spencer*	1939	120	0	84,600	10,159
89	Eureka, *Spencer*	1942	10	0	2,300	2,300
90	Hatfield, *Spencer*	1941	30	0	179,400	71,900
91	Rock Hill, *Spencer*	1928	310	0	76,700	11,700
92 93	Rockport, *Spencer*	1939	140	0	71,100	20,200
94	Gentryville, *Spencer, Warrick*		260	0	*y*	2,400
95 96	Dodds Bridge, *Sullivan*	*y*	400	0	*y*	77,700
97	Marts, *Sullivan*	1932	0	200	0	0
98 99 100	Shelburn-Sullivan, *Sullivan*[6]	1911	5,120	660	7,154,900	54,900
101	Vanderburgh, *Vanderburgh*	1931	600	0	485,900	28,000
102	Vaughn, *Vanderburgh*[1]	1941	120	0	1,200	1,000
103	Vienna, *Vanderburgh*[7]	1933	350	0	463,700	30,700
104	Vernon Heights, *Vanderburgh*	1941	90	0	21,600	21,600
105	Prairie Creek, *Vigo*	1937	460	0	599,100	84,800
106	Riley, *Vigo*	1906	310	0	138,400	300
107	Siosi, *Vigo, Sullivan*	1926	880	0	3,120,000	117,800
108	Millersburg, *Warrick*[1]	1941	20	0	2,700	0
109			158,280	704,210	137,000,300	6,609,000[8]

[3] Gas first marketed in 1942.
[6] Formerly called Shelburn-Graysville.
[7] Formerly called Blairsville.
[8] U. S. Bureau of Mines total.

TABLE I.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
				During 1942		End of 1942			Number of Wells						
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
60	0	0	10	0	0	0	10	0	0	10	y	y		33.0	y
61															
62	0	0	34	10	0	0	34	0	0	34	y	y		33.0	y
63															
64															
65	0	0	7	0	2	0	5	0	0	5	y	y		34.0	y
66	0	0	6	0	0	0	3	0	0	3	y	y		38.5	y
67	0	0	1	1	1	0	0	0	0	0	y	y		36.0	y
68	0	0	1	1	0	0	1	0	0	1	y	y		y	y
69	0	0	1	1	0	0	1	0	0	1	y	y		y	y
70	0	0	4	4	0	0	4	0	0	4	y	y		35.5	y
71	0	0	22	12	0	0	22	0	0	22	y	y		35.5	y
72															
73	0	0	26	0	0	0	26	0	0	26	y	y	PM	36.5	y
74															
75															
76	0	0	1	1	0	0	1	0	0	1	y	y		y	y
77	0	0	1	1	0	0	1	0	0	1	y	y		39.0	y
78	0	0	1	1	0	0	1	0	0	1	y	y		y	y
79	0	0	1	0	0	0	0	0	0	0	x			39.0	y
80	0	0	1	1	0	0	1	0	0	1	y	y		y	y
81	0	0	28	0	0	0	26	0	0	26	y	y		y	y
82	0	0	2	2	0	0	2	0	0	2	y	y		38.5	y
83	0	0	1	0	0	0	1	0	0	1	y	y		36.0	y
84	0	0	51	2	0	0	43	0	0	43	y	y		35.0	y
85															
86	47.8	47.8	12	2	0	0	0	12			y	y			
87	0	0	6	1	0	0	6	0	0	6	y	y		36.0	y
88															
89	0	0	1	1	0	0	1	0	0	1	y	y		38.0	y
90	0	0	14	3	0	0	14	0	0	14	y	y		34.0	y
91	0	0	24	5	0	0	21	0	0	21	y	y		34.0	y
92	1,449.8	594.3	64	1	0	0	15	38	0	15	y	y		33.5	y
93															
94	0	0	13	0	1	0	3	0	0	3	x	y		y	y
95	0	0	101	0	0	0	55	0	0	55	x	y		y	y
96			6	6	0	0	6	0	0	6	y	y		46.0	y
97	y	25.0	16	0	1	0	0	9			y	y			
98	1,032.0	32.0	1,000	1	13	0	275	18	0	275	110	y		35.0	y
99															
100															
101	0	0	95	0	3	0	53	0	0	53	x	y		30.5	y
102	0	0	1	0	0	0	0	0	0	0	x			34.0	y
103	0	0	102	0	0	0	34	0	0	34	x	y		29.0	y
104	0	0	9	9	0	0	9	0	0	9	y	y		y	y
105	0	0	24	0	1	0	14	0	0	14	y	y		37.0	y
106	0	0	33	0	0	0	1	0	0	1	x	y		50.0	y
107	0	0	86	1	3	0	47	0	0	47	x	y		39.0	y
108	0	0	1	1	1	0	0	0	0	0	x	x		x	x
109	811,485.3	1,627.3	31,256	146	108	0	2,064	417	0	2,064					

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age^e	Character^f	Porosity^g	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure^h	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
60	Pennsylvanian	Pen	S	Por	634 1,130	669 1,153	y 23	A	St. Louis	2,863
61	Cypress	MisU	S	Por	2,382	2,400	18			
62	Pennsylvanian	Pen	S	Por	362 1,095	409 1,118	9 12	A	MisL	2,727
63	Tar-Springs	MisU	S	Por	1,990	2,000	10			
64	Cypress	MisU	S	Por	2,367	2,387	10			
65	Cypress	MisU	S	Por	2,497	2,503	6	A	MisL	2,670
66	Aux Vases	MisU	S	Por	2,565	2,584	10	D	Ste. Genevieve	2,687
67	Tar Springs	MisU	S	Por	2,139	2,146	7	D	MisL	3,010
68	Aux Vases	MisU	S	Por	2,609	2,653	11	D	MisL	2,653
69	Pennsylvanian	Pen	S	Por	1,095	1,105	10	D	Pen	1,135
70	Tar Springs	MisU	S	Por	1,945	1,951	6	D	Ste. Genevieve	2,812
71	Waltersburg	MisU	S	Por	2,000	2,050	18	A	St. Louis	3,000
72	Cypress	MisU	S	Por	2,425	2,470	23			
73	Waltersburg	MisU	S	Por	2,172	2,207	35	A	St. Louis	3,028
74	Tar Springs	MisU	S	Por	2,295	2,305	10			
75	McClosky	MisL	Ls	Por	2,968	2,978	3			
76	Cypress	MisU	S	Por	2,457	2,464	7	A	MisL	2,925
77	McClosky	MisL	Ls	Por	2,739	2,760	4	D	MisL	2,908
78	McClosky	MisL	Ls	Por	2,839	2,968	12	D	MisL	2,968
79	McClosky	MisL	Ls	Por	2,972	2,978	6	D	MisL	3,109
80	McClosky	MisL	Ls	Por	2,737	2,742	5	D	MisL	2,742
81	Mansfield	PenL	S	Por	1,007	1,031	30	ML	Chester	1,920
82	McClosky	MisL	Ls	Por	2,612	2,621	7	D	MisL	2,621
83	Cypress	MisU	S	Por	2,476	2,506	30	D	Ste. Genevieve	2,817
84	Waltersburg	MisU	S	Por	1,750	1,800	25			
85	Tar Springs	MisU	S	Por	1,855	1,920	25	AF	Ste. Genevieve	2,643
86	Trenton	Ord	Ls	Por	1,040	1,060	12	A	Trenton	1,060
87	Cypress	MisU	S	Por	1,404	1,411	8	D	MisL	1,745
88	McClosky	MisL	Ls	Por	1,571	1,654	8			
89	McClosky	MisL	Ls	Por	1,652	1,674	2	D	MisL	1,674
90	Waltersburg	MisU	S	Por	1,029	1,044	15	A	St. Louis	1,783
91	Sample	MisU	S	Por	1,310	1,320	10	MC	Ste. Genevieve	1,500
92	Pennsylvanian	PenL	S	Por	885	905	10	A	St. Louis	1,707
93	Palestine	MisU	S	Por						
94	Tar Springs	MisU	S	Por	725	758	33	D	MisL	1,241
95	Pennsylvanian	PenL	S	Por	634 656 700	656 683 730	y	A	Devonian	2,386
96	Devonian	Dev	Ls	Por	2,337	2,386	13			
97	Pennsylvanian	Pen	S	Por	313	344	9	D	Pennsylvanian	628
98	Pennsylvanian	Pen	S	Por	298 560 640 730 800	325 595 667 775 810	y	AM	Silurian	2,870
99	Harrodsburg	MisL	Ls	Por	1,400	1,500	y			
100	Silurian	Sil	Ls	Por	2,270	2,285	y			
101	Mansfield	PenL	S	Por	899	911	y	ML	Ste. Genevieve	2,435
102	Waltersburg	MisU	S	Por	1,647	1,655	8	D	MisL	2,562
103	Mansfield	PenL	S	Por	1,007	1,031	30	ML	Chester	1,920
104	Waltersburg	MisU	S	Por	1,770	1,786	16	A	MisU	1,824
105	Niagaran	Dev-Sil	Ls	Por	2,074	2,165	y	D	Silurian	2,232
106	Niagaran	Dev	Ls	Por	1,600	1,700	y	A	Niagaran	1,802
107	Niagaran	Dev-Sil	Ls	Por	2,100	2,115	y	D	Trenton	3,554
108	McClosky	MisL	Ls	Por	1,887	1,890	3	D	MisL	1,956
109										

TABLE 2.—*Completions by Counties in Indiana in 1942*

County	Completions	Producers		Total Initial Production		Footage Drilled
		Oil	Gas	Oil, Bbl.	Gas, Cu. Ft.	
Adams	1	0	0	0	0	1,063
Benton	1	0	0	0	0	1,154
Cass	1	0	0	0	0	1,054
Crawford	1	0	0	0	0	1,200
Daviess	21	6	3	85	3,950,000	16,933
Decatur	5	0	5	0	480,000	4,608
Dubois	2	0	0	0	0	1,535
Gibson	77	38	2	2,801	4,180,000	141,654
Green	1	0	0	0	0	1,270
Hamilton	2	0	0	0	0	1,610
Harrison	4	0	0	0	0	4,603
Henry	1	0	1	0	1,500	908
Jay	6	2	1	45	10,000	6,739
Knox	8	2	1	22	120,000	14,328
LaPorte	1	0	0	0	0	147
Lawrence	1	0	0	0	0	1,856
Madison	1	0	0	0	0	1,018
Marshall	1	0	0	0	0	301
Martin	1	0	0	0	0	485
Monroe	1	0	0	0	0	1,830
Morgan	1	0	0	0	0	1,700
Owen	1	0	0	0	0	3,199
Perry	2	0	0	0	0	1,650
Pike	14	3	2	32	2,150,000	11,644
Porter	2	0	0	0	0	1,233
Pulaski	1	0	0	0	0	949
Posey	94	44	0	4,661	0	220,127
Randolph	5	1	2	5	27,000	5,704
Rush	3	0	3	0	155,000	2,679
St. Joseph	1	0	0	0	0	300
Spencer	36	12	0	482	0	41,878
Starke	1	0	0	0	0	2,700
Sullivan	19	6	1	1,083	75,000	35,290
Vanderburgh	23	9	0	648	0	45,264
Vigo	2	1	0	70	0	2,838
Warrick	5	1	0	40	0	7,085
White	2	0	0	0	0	1,198
	349	125	21	9,974	11,148,500	589,734

TABLE 3.—*Wildcat Wells Drilled in Indiana in* 1942

	County	Company and Farm	Location		Total Depth, Ft.	Deepest Formation Tested	Initial Production, Bbl.	Pool Name	Date of Completion	Remarks
1	Adams	K. O. Reiff, J. H. Reiff No. 1	SE SE SW	16-25N-13E	1,063	Trenton	Dry		10-10-42	
2	Benton	Hynes, Atkinson No. 1	NW NW NW	3-25N- 7W	1,154	Trenton	Dry		3- 5-42	
3	Cass	National Petroleum, Puthal No. 1	C NW SE	22-28N- 1W	1,054	Trenton	Dry		2- 2-42	
4	Crawford	Reese et al., Esarey No. 1	NE NW NE	36- 3S - 1W	1,200	Devonian	Dry		5- 1-42	
5	Daviess	Dawson, Wolfenberger No. 1	C S½ SE SW	35- 5N- 7W	1,000	St. Louis	Dry		1-28-42	
6	Dubois	Detrick, Fleig No. 1	NE NE SE	9- 3S - 4W	1,165	Salem	Dry		8-29-42	
7	Dubois	Lane, Fleig No. 2	SW NE SE	9- 3S - 4W	370	Tar Springs	Dry		9-15-42	
8	Gibson	Kingwood, Fithian, No. 1	C E½ SE SE	23- 1N-10W	3,450	Devonian	140	Hazelton[a]	4- 1-42	P. B. 2447 Osage ls.
9	Gibson	Kingwood, Potts No. 1-A	C E½ NE SE	23- 1N-10W	2,112	McClosky	55	Hazelton[b]	2-12-42	
10	Gibson	Benoist, Dunn No. 1	Location	5- 1N-10W	1,935	McClosky	84	Hazelton[b]	2-15-42	P. B. 1800
11	Gibson	McGinnis and Bitler, Trippet No. 1	Donation	54- 1S -10W	1,942	Ste. Genevieve	Dry		4-20-42	
12	Gibson	McGinnis and Bitler, Schmidt No. 1	N½ SE SE	26- 1S -10W	1,348	Hardinsburg	35	Kirksville[b]	6-22-42	
13	Gibson	Heussler, Morratta No. 1	C W½ SE SW	34- 1S -10W	2,017	Ste. Genevieve	Dry		4-12-42	
14	Gibson	R. D. Brown, Sinkhorn No. 1	NE SW NW	36- 1S -10W	1,413	Hardinsburg	50	Kirksville[b]	10- 7-42	
15	Gibson	Superior Oil Co., Hull No. 1	SE NE SW	30- 1S -11W	2,396	Ste. Genevieve	Dry		12-23-42	
16	Gibson	Travis, Howard No. 1	SE NE SE	35- 1S -11W	921	Pennsylvanian	Dry		5- 9-42	
17	Gibson	Mo-Jo Oil Co., Mason Com. No. 1	NW NW SE	35- 2S - 9W	1,137	Tar Springs	25	Somerville[c]	5-24-42	
18	Gibson	R. D. Brown, Blood No. 1	SE NE SE	36- 2S -13W	1,102	Pennsylvanian	35	Johnson[b]	3- 4-42	
19	Gibson	Clark, Townsley No. 1	NW NE NW	2- 3S - 9W	1,782	Ste. Genevieve	Dry		8-24-42	
20	Gibson	Graham, Thompson No. 1	N½ SW SW	11- 3S -12W	2,685	St. Louis	Dry		1- 1-42	
21	Gibson	Dickerson-Libernecht, Stemkle No. 1	C S½ SE SE	11- 3S -13W	2,785	Ste. Genevieve	Dry		1-11-42	
22	Gibson	Continental Oil Co., Young No. 1	SE SE NW	12- 3S -13W	3,316	Lower Mississippian	Dry		12-23-42	
23	Greene	Kentucky Natural Gas Co., Dilly No. 1	C SE SW	17- 8N- 3W	1,270	Devonian	Dry		9-21-42	
24	Harrison	Davis, Fee No. 1	SW SW SE	26- 2S - 3E	926	Devonian	Dry		3- 5-42	
25	Jay	Smith et al., Scheffer No. 1	C W½ NW NW	22-22N-15E	1,213	Trenton	Dry		5-16-42	
26	Knox	Bauer, Kuhn No. 1	NW NE NE	2- 1N- 9W	1,650	St. Louis	Dry		7-29-42	
27	Knox	Carter, Holtman No. 1	Survey	44- 2N-10W	1,900	Ste. Genevieve	Dry		11-17-42	
28	Knox	Miller, Lewis No. 1	C N½ NW SE	26- 2N-11W	1,895	McClosky	10	St. Thomas[b]	6-17-42	
29	Knox	Sinclair Wyoming, Brevort No. 1	SW SW SE	15- 2N-11W	1,936	McClosky	12	St. Francisville[b]	4- 5-42	P. B. 1772 Bethel
30	Knox	Miller and McBride, Brevort No. 1-A	Survey	39- 2N-11W	1,880	Ste. Genevieve	Dry		9-22-42	
31	Knox	Bauer, Ritter No. 1	NW SW	35- 3N-10W	1,922	St. Louis	Dry		6- 6-42	

32	Knox	Cherry and Kidd, Steckler No. 1	C SW NE NW	13- 1S-12W	2,368	Ste. Genevieve	Dry		5-19-42	
33	La Porte	Hostetler, Zahn No. 1	SE SW SW	14-33N- 4W	147	Devonian	Dry		7-17-42	
34	Lawrence	Lesh, Ray No. 1	NE SW NE	3- 5N- 1E	1,856	Trenton	Dry		9-24-42	
35	Marshall	Short, Schroeder No. 1	NE NE NW	6-34N- 1E	301	Devonian	Dry		10- 3-42	
36	Martin	Burton and Brewer, Burris No. 1	NE NW	16- 2N- 4W	485	Lower Mississippian	Dry		1-17-42	
37	Monroe	Bunting and Deskine, Cowling No. 1	SW SW NW	34- 7N- 1E	1,830	Trenton	Dry		6-18-42	
38	Morgan	Jefferson, Brown No. 1	NW NW NE	16-13N- 1W	1,700	Trenton	Dry		2-28-42	
39	Owen	Sun Oil Co., Chambers No. 1	C E½ SW SE	23-10N- 5W	3,199	St. Peter	Dry		11- 6-42	
40	Perry	United Oil Co., Polk No. 1	SE NW SE	7- 7S- 2W	900	Ste. Genevieve	Dry		8-24-42	
41	Perry	Zanetis, Amer. Canal Coal Co. No. 1	W½ SE	10- 7S- 3W	750	Ste. Genevieve	Dry		8- 1-42	
42	Pike	Siosi Oil Co., Enos Coal Co. No. 1	C NE NE NE	18- 1S- 8W	1,848	St. Louis ls.	Dry		6-21-42	
43	Pike	Yingling, Blaize No. 1	C N½ NE NW	12- 1S- 9W	1,685	Renault	Dry		5-12-42	
44	Pike	Steed, Orion No. 1	C SW NE	3- 3S- 7W	1,320	Ste. Genevieve	Dry		3-18-42	
45	Pike	Skelly Oil Co., Sollman No. 1	SW SE NE	14- 3S- 7W	1,502	Ste. Genevieve	Dry		6-22-42	
46	Pike	Dawson, Erwin et al. No. 1	SE SW NW	16- 3S- 7W	1,404	Ste. Genevieve	Dry		2- 7-42	
47	Porter	Hoststetler, Goodpaster No. 1	NW SE SE	10-32N- 5W	146	Devonian	Dry		9- 7-42	
48	Porter	Hynes, Dell No. 1	SW SW NE	1-33N- 7W	1,087	Trenton	Dry		7-21-42	
49	Posey	Wabash O. and G. Assn., Mumford No. 1	SW NW NE	31- 3S-13W	3,004	McClosky	8	Griffin[b]	2-10-42	
50	Posey	Mahutska Oil Co., Holman No. 1	NW NE NW	5- 4S-13W	2,480	Cypress	25	Mumford Hills[b]	9-20-42	
51	Posey	Yost and Lambert, Pfister No. 1	C N½ NE SW	23- 4S-13W	3,015	Ste. Genevieve	Dry		1-13-42	
52	Posey	Cherry and Kidd, Bailey No. 1	C E½ SE NE	4- 5S-13W	3,039	St. Louis	Dry		7- 1-42	
53	Posey	Calstar Petr. Co., Shoultz No. 1	SE NE SW	12- 5S-14W	3,075	Ste. Genevieve	Dry		8-30-42	
54	Posey	Martin, Stowling No. 1	NW NW SE	25- 5S-14W	2,609	Cypress	Dry		10-12-42	
55	Posey	Rossi, Williman No. 1	SE SE SE	18- 6S-12W	2,353	Cypress	21	Caborn[b]	9-22-42	P. B. 1860 Walt.
56	Posey	Lindas, Seifert No. 1	SW NW NE	30- 6S-12W	1,152	Pennsylvanian	30	Caborn[b]	10-12-42	
57	Posey	Jarvis Bros., Walker No. 1	S½ NW SE	33- 6S-12W	2,875	Ste. Genevieve	Dry		6-23-42	
58	Posey	Carter Oil Co., Duckworth No. 1	C SW SE	6- 6S-13W	3,106	St. Louis	Dry		6-30-42	
59	Posey	Carter Oil Co., Keltz No. 1	C NE NW	8- 6S-13W	3,051	St. Louis	Dry		4- 8-42	
60	Posey	Gulf Ref. Co., Strack No. 1	C NE NE	30- 6S-13W	3,028	St. Louis	Dry		6-30-42	
61	Posey	J. W. Carter, Aldredge No. 1	C SE NW	22- 6S-14W	3,015	Ste. Genevieve	Dry		8-18-42	
62	Posey	Carter Oil Co., Allyn No. 1	C NW NE	28- 6S-14W	3,010	Ste. Genevieve	6	Grafton[b]	4- 8-42	P. B. 2146 Tar Spgs.
63	Posey	Parris, Spencer No. 1	C SE SE	28- 6S-14W	2,990	Ste. Genevieve	Dry		8- 8-42	
64	Posey	Tide Water Assn., Oeth No. 1	C SW SW	5- 7S-12W	2,633	Aux Vases	15	Stooker[b]	5-10-42	

[a] Deeper producing formation. [b] Extension. [c] New pool.

TABLE 3.—(*Continued*)

	County	Company and Farm	Location	Total Depth, Ft.	Deepest Formation Tested	Initial Production, Bbl.	Pool Name	Date of Completion	Remarks
65	Posey........	Gulf Ref. Co., Schutte No. 1	C NE NW 8- 7S-12W	2,832	Ste. Genevieve	Dry		5-25-42	
66	Posey........	Rossi, Mauzy	NE NW NW 8- 7S-12W	2,621	McClosky	219	Stooker[c]	4-15-42	
67	Posey........	Smokey Oil Co., Etna Life Ins. Co. No. 1	NE NW SW 17- 7S-12W	2,761	Ste. Genevieve	Dry		6- 1-42	
68	Posey........	Lindas, Spencer No. 1	SE NW NW 24- 7S-13W	1,187	Pennsylvanian	Dry		6-15-42	
69	Posey........	Lindas, Thomas No. 1	NE NE SE 24- 7S-13W	2,375	Cypress	Dry		1-16-42	
70	Posey........	Carter Oil Co., Baker No. 1	C SE NE 8- 7S-14W	2,948	Ste. Genevieve	Dry		4-30-42	
71	Posey........	Cherry and Kidd, Kock No. 1	SE SW SW 8- 7S-14W	2,941	St. Louis	Dry		10- 4-42	
72	Posey........	Carter Oil Co., Hancock No. 1	C NW SW 9- 7S-14W	2,961	St. Louis	Dry		9-22-42	
73	Posey........	Carter Oil Co., Baker No. 1	C SW NW 9- 7S-14W	2,963	McClosky	262	Prairie[c]	3-20-42	
74	Posey........	Carter Oil Co., Black No. 1	C NE SE 11- 7S-14W	2,919	McClosky	90	Mt. Vernon[b]	8-20-42	
75	Posey........	Longhorn Oil Corp., Greathouse No. 2	SW NE NE 18- 7S-14W	2,925	Ste. Genevieve	108	New Haven[b]	9-20-42	P. B. 2464 Cypress
76	Posey........	Gulf Ref. Co., Reis No. 1	C W½ SW NW 23- 7S-14W	2,742	McClosky	20	Ridge[c]	8-10-42	
77	Posey........	Fleming, Morelock No. 1	NW SE NW 26- 7S-14W	2,689	Ste. Genevieve	Dry		4-30-42	
78	Posey........	Sinclair Wyoming, Nash No. 1	SW SW NE 32- 7S-14W	2,908	McClosky	227	Point[c]	3- 4-42	
79	Posey........	Longhorn Oil Corp., Greathouse No. 1	NW SE SE 11- 7S-15W	2,992	Ste. Genevieve	Dry		7-21-42	
80	Posey........	Sun Oil Co., Byrd No. 1	C NE SE 4- 8S-14W	2,653	Aux Vases	53	Half Moon[c]	4-20-42	
81	Posey........	Sun Oil Co., Bennett No. 1	C SE SE 4- 8S-14W	2,748	St. Louis	Dry		7- 2-42	
82	Posey........	Brehm, Hardwick No. 1	SE SE SE 12- 8S-14W	1,135	Pennsylvanian	24	Hovey Lake[c]	10-28-42	
83	Posey........	Brehm, Hageman No. 1	SE SW SE 12- 8S-14W	2,590	Cypress	Dry		10-25-42	
84	Posey........	Dearing, Schneider No. 1	C N½ NE NE 30- 8S-14W	2,780	Aux Vases	Dry		12-23-42	
85	Posey........	Sohio Producing Co., Eilert No. 1	SE NE NW 18- 8S-13W	2,796	Ste. Genevieve	Dry		12- 9-42	
86	Pulaski......	Lyons, Huff	NW NW SW 24-29N- 2W	949	Trenton	Dry		5-27-42	
87	Randolph....	Seip, Ward No. 1	NE NW NW 10-20N-14E	1,310	Trenton	Dry		1-10-42	
88	Randolph....	Seip, Fraze No. 1	SW SE SE 28-21N-14W	1,092	Trenton	Dry		11- 1-42	
89	St. Joseph....	William et al., Hay No. 1	NE NE SE 25-36N- 1W	300	Devonian	Dry		1-30-42	
90	Spencer......	Travis, Haff Hrs. No. 1	C SE NW 20- 6S - 5W	1,200	Ste. Genevieve	Dry		5-10-42	
91	Spencer......	Troy Ref. Corp., Hayden No. 1	C SW SW 22- 6S - 5W	950	Bethel	Dry		7-30-42	

92	Spencer......	Miller and Shiarella, West No. 1	SW NW SW	33- 6S - 7W	1,012	Waltersburg	Dry		9-14-42	
93	Spencer......	Spencer Dev. Co., Hoffman No. 1	NW SE SE	11- 7S - 7W	1,562	Ste. Genevieve	Dry		5- 1-42	
94	Spencer......	Spencer Dev. Co., Abshire No. 1	NE NE NW	14- 7S - 7W	1,618	Ste. Genevieve	Dry		11-10-42	
95	Spencer......	Mitchell et al., Ellen No. 1	SW SE NE	26- 7S - 7W	1,404	Cypress	Dry		7-19-42	
96	Spencer......	Miller and Shiarella, Locker No. 1	NW SW NW	34- 7S - 7W	1,674	McClosky	80	Eureka[c]	8-21-42	
97	Spencer......	Gary, Frank No. 1	SW SW	36- 7S - 7W	951	Palestine	11	Enterprise[b]	4- 6-42	
98	Spencer......	Campbell et al., Wilkinson No. 1	C NE NW	3- 8S - 7W	1,650	Ste. Genevieve	Dry		7- 3-42	
99	Starke.......	Short, Peterson	NE NE NE	1-34N- 1W	300	Devonian	Dry		8-15-42	
100	Sullivan......	Sun Oil Co., Queen	C W½ SE NW	17- 6N- 9W	2,700	Devonian	Dry		2-11-42	
101	Sullivan.....	Sun Oil Co., Knotts and Pifer No. 1	Survey	19- 6N- 9W	1,389	Ste. Genevieve	Dry		4- 1-42	
102	Sullivan.....	Sun Oil Co., Poston No. 1	C SW NW	34- 7N- 9W	1,285	Ste. Genevieve	Dry		5-10-42	
103	Sullivan.....	Self et al., Land No. 1	NE NE NE	36- 7N- 9W	2,508	Devonian	Dry		2-28-42	
104	Sullivan.....	Ohio Oil Co., Poe No. 1	NE NE SW	3- 8N-10W	2,386	Devonian	77	Dodds Bridge[a]	6-25-42	Deepd. from 1477 ft.
105	Sullivan.....	Bailey, Mann No. 2	SE SE SW	25- 8N-11W	390	Pennsylvanian	Dry		8- 1-42	
106	Sullivan.....	Gilliam, Woodward No. 1	C SW SW	34- 9N-10W	2,417	Devonian	Dry		10-19-42	
107	Vanderburgh.	Doaner, Bixler No. 1	SE NE NW	21- 4S -11W	2,592	Ste. Genevieve	Dry		1-17-42	
108	Vanderburgh.	Riddle, Jacquemai No. 1	C S½ NE SE	15- 5S -11W	2,665	Ste. Genevieve	Dry		5- 4-42	
109	Vanderburgh.	Eslick, Karn No. 1	SE NW NW	19- 6S -11W	2,730	Ste. Genevieve	Dry		4-15-42	
110	Vanderburgh.	Amerlagene, Eichele No. 1	C NE NW	29- 6S -11W	2,678	St. Louis	Dry		4- 7-42	
111	Vanderburgh.	Sells Petrol. Co., Mc Carthy No. 1	NE SW NW	32- 6S -11W	1,736	Waltersburg	170	Vernon Heights[b]	3- 4-42	
112	Vanderburgh.	Sells Petrol. Co., Wellborne No. 1	E½ NE SW	32- 6S -11W	1,824	Walterburg	Dry		2-15-42	
113	Vanderburgh.	Glenwood Oil Co., Kamp No. 1	C NW SW	15- 7S -11W	1,652	Waltersburg	Dry		4- 5-42	
114	Vanderburgh.	Case and Pomeroy, Edmonds No. 1	NW NW NW	16- 7S -11W	1,669	Waltersburg	Dry		7- 2-42	
115	Vanderburgh.	Yingling, Gerlach No. 1	NE SE SW	17- 7S -11W	1,771	Waltersburg	Dry		8-16-42	
116	Vanderburgh.	Riddle, Hutchinson No. 1	C NW NE	33- 7S -11W	2,565	Ste. Genevieve	Dry		7- 7-42	
117	Vigo.........	Bailey, Hill No. 1	SE SW NW	34-10N -9W	626	Pennsylvanian	Dry		5-12-42	
118	Warrick.....	Kenn-Penn Oil Corp., Metz No. 1	SE SW NW	10- 6S - 7W	1,567	Ste. Genevieve	Dry		1-21-42	
119	Warrick.....	Hollingsworth, Ezell No. 1	NE SW SE	36- 6S - 8W	1,842	Ste. Genevieve	Dry		6-10-42	
120	Warrick.....	Forest, Sutton No. 1	SW SE SW	35- 4S - 6W	1,172	McClosky	40	Gentryville[b]	4-13-42	
121	White.......	Ohio Oil Co., Mathews No. 1	SW SW NW	11-26N- 6W	1,060	Trenton	Dry		6-17-42	
122	White.......	McNeil, Kimberly No. 1	C S½ NW NW	15-27N- 6W	138	Devonian	Dry		9-15-42	
					231,702					

[a] Deeper producing formation.

[b] Extension.

[c] New pool.

TABLE 4.—*New Pools Discovered in Indiana in* 1942

Field	County	Company and Farm	Location	Total Depth, Ft.	Producing Formation	Depth to Top, Ft.	Initial Production, Bbl.	Date of Completion	Number of Wells in Pool 12/31/42
Stooker	Posey	Rossi, Mauzy No. 1	NE NW NW 8-7S -12W	2,621	McClosky ls.	2,612	219	4-15-42	1
Prairie	Posey	Carter Oil Co., Baker No. 1	SW SW NW 9-7S -14W	2,968	McClosky ls.	2,839	262	3-20-42	1
Point	Posey	Sinclair-Wyoming, Nash No. 1	SW SW NE 32-7S -14W	2,908					
				P. B. 2,760	McClosky ls.	2,739	227	3- 4-42	1
Half Moon	Posey	Sun Oil Co., Byrd No. 1	C NE SE 4-8S -14W	2,653	Aux Vases ss.	2,609	53	4-20-42	1
Ridge	Posey	Gulf Ref. Co., Reis	C W½ SW NW 23-7S -14W	2,742	McClosky ls.	2,737	20	8-10-42	1
Eureka	Spencer	Miller et al., Locker No. 1	NW SW NW 34-7S - 7W	1,674	McClosky ls.	1,652	80	8-21-42	
Hovey Lake	Posey	Brehm, Hardwick No. 1	SE SE SE 12-8S -14W	1,135					
				P. B. 1,105	Pennsylvanian ss.	1,095	24	10-28-42	1
Dodds Bridge[a]	Sullivan	Ohio Oil Co., Poe No. 1	NE NE SW 3-8N-10W	2,386					1
			Deepened from	1,417	Devonian ls.	2,337	77	6-25-42	6
Somerville	Gibson	Mo-Jo Oil Co., Mason Community No. 1	NW NW SE 35-2S - 9W	1,137	Tar Springs ss.	1,117	25	5-24-42	2
Grafton[b]	Posey	Carter Oil Co., Allyn No. 1	NW NW NE 28-6S -14W	3,010					
				P. B. 2,146	Tar Springs ss.	2,139	10	4- 8-42	0
Hazelton	Gibson	Kingswood, Fithian No. 1	E½ SE SE 23-1N-10W	3,450					
				P. B. 2,447	Osage ls.	2,402	140	4- 1-42	17

[a] Deeper production in field.
[b] Abandoned.

TABLE 5.—*Extensions to Fields in Indiana in* 1942

Field	County	Company and Farm	Location	Total Depth, Ft.	Depth to Top, Ft.	Producing Formation	Initial Production, Bbl.	Date of Completion
Hazelton	Gibson	Kingwood, Potts No. 1-A	E½ NE SE 23-1N-10W	2,112	1,706	McClosky ls.	55	2-12-42
Kirksville	Gibson	Brown, Sinkhorn No. 1	NE SW NW 36-1S -10W	1,413	1,385	Hardinsburg ss.	50	10- 7-42
Kirksville	Gibson	McGinnis and Bitler, Michel No. 1	NE SE SE 26-1S -10W	1,348	1,315	Hardinsburg ss.	35	6-22-42
Hazelton	Gibson	Benoist, Dunn No. 1	SW SW SE 24-1N-10W	1,935 P. B. 1,800	1,744	McClosky ls.	84	2-15-42
Johnson	Gibson	Brown, Blood No. 1	SE NE SE 36-2S -13W	1,102	1,096	Pennsylvanian	35	3- 4-42
St. Thomas	Knox	Miller, Lewis No. 1	NW NW SE 26-2N-11W	1,895	1,885	McClosky ls.	10	6-24-42
St. Francisville	Knox	Sinclair Wyoming, Brevoort No. 1	SW SW SE 15-2N-11W	1,936 P. B. 1,772	1,738	Bethel ss.	12	4- 5-42
Stooker	Posey	Tidewater, Oeth No. 1	SE SW SW 5-7S -12W	2,633	2,619	Aux Vases ss.	15	5-10-42
New Haven	Posey	Longhorn, Greathouse No. 2	SW NE NE 18-7S -14W	2,925 P. B. 2,464	2,457	Cypress ss.	108	9-20-42
Mumford Hills	Posey	Mahutska Oil Co., Holman No. 1	NW NE NW 5-4S -13W	2,480	2,454	Cypress ss.	25	9-20-42
Mt. Vernon	Posey	Carter Oil Co. and Gulf Ref., Black No. 1	C NE SE 11-7S -14W	2,919	2,744	McClosky ls.	90	8-20-42
Caborn	Posey	Rossi, Willman No. 1	SE SE SE 18-6S -12W	2,353 P. B. 1,860	1,850	Waltersburg ss.	21	9-22-42
Caborn	Posey	Lindas, Seifert No. 1	SW NW NE 30-6S -12W	1,152	1,135	Pennsylvanian ss.	30	10-12-42
Griffin	Posey	Wabash O. and G. Assn., Mumford No. 1	SW NW NE 31-3S -13W	3,004	2,847	McClosky ls.	8	2-10-42
Enterprise	Spencer	Geary, Frank No. 1	NW SE SE 36-7S - 7W	951	947	Palestine ss.	11	4- 6-42
Vernon Heights	Vanderburgh	Sells Petrol. Co., McCarthy No. 1	NE SW NW 32-6S -11W	1,736	1,718	Waltersburg ss.	170	3- 4-42
Gentryville	Warrick	Forrest, Sutton No. 1	SW SE SW 35-4S - 6W	1,172	1,165	McClosky ls.	40	4-13-42

fields and $1.37 for the new fields in southwestern Indiana. In the old Trenton field in northeastern Indiana the producers received $1.60 a barrel for the crude, which was used as fuel oil.

TABLE 6.—*Wildcat Completions in Indiana in* 1942

County	Completions	Producers
Adams	1	0
Benton	1	0
Cass	1	0
Crawford	1	0
Daviess	1	0
DuBois	2	0
Gibson	15	7*
Greene	1	0
Harrison	1	0
Jay	1	0
Knox	7	2
LaPorte	1	0
Lawrence	1	0
Marshall	1	0
Martin	1	0
Monroe	1	0
Morgan	1	0
Owen	1	0
Perry	2	0
Pike	5	0
Porter	2	0
Posey	37	14
Pulaski	1	0
Randolph	2	0
St. Joseph	1	0
Spencer	9	2
Starke	1	0
Sullivan	7	1*
Vanderburgh	10	1
Vigo	1	0
Warrick	3	1
White	2	0
	1[illegible]	[illegible]8

* One well, deeper production found.

Natural gas produced and marketed during the year totaled 1,630,000,000 cu. ft. The Rockport gas field, Spencer County, ranked first, with the production of 594,316,000 cu. ft. The Unionville field, Monroe County, and Greensburg field, Decatur County, were second and third, with 239,856,000 and 210,827,000 cu. ft., respectively.

There was very little pipe-line activity in the state during 1942. Short lines were constructed in southwestern Indiana to provide outlets to the new fields and Gulf Pipe Line Corporation completed the "loops" in its main line to Dublin, Indiana.

Repressuring is being conducted in the Griffin field with the dry gas from the Warren Petroleum Company's natural gasoline plant on the Illinois side of the Wabash River. This plant was put in operation in August 1942, and to the end of the year it had processed approximately 500,000,000 cu. ft. of gas from the Griffin field. At the present time approximately 1,530,000 cu. ft. of dry gas is injected daily into the producing sands in the field, through 14 input wells. The Waltersburg sand in the Ribeyre Island portion of the New Harmony field is being repressured with 360,000 cu. ft. of dry gas per day from the same plant through four input wells.

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Oil Industry in Kansas during 1942

By W. A. Ver Wiebe*

Under the impetus of new demands caused by the war, the oil and gas industries of Kansas established new records during the year 1942. In all, 1513 test wells were drilled, which is somewhat of a drop from the figure of 2113 for 1941. The 1513 tests yielded 800 new oil wells, 85 new gas wells, and 628 dry holes. Thus there was an increase in two categories, the gas wells and the dry holes. Considering that last year only 592 dry holes were completed out of a much larger total, the figure of 628 dry holes causes some concern among local operators. The increase in unsuccessful tests illustrates once more the fact that each year it is becoming harder to find the remaining oil pools.

When the figures are broken down, it appears that western Kansas accounted for 1177 tests, of which 689 were oil wells, 33 gas wells, and 455 dry holes. The total potential daily initial production uncovered by the successful wells amounted to 753,178 bbl. of oil and 619,734,000 cu. ft. of gas. The figures for new initial production indicate a substantial drop from last year's figure of 1,691,000 bbl., and the figures on gas are slightly higher. In 1941 the new gas as based on a daily potential was 508,000,000 cu. ft.

In eastern Kansas, 336 wells were drilled. Among these 111 were oil wells, accounting for a daily initial potential production of 16,199 bbl. The new gas wells numbered 52 and added 253,725,000 cu. ft. per day to the gas potential production of the state. The remaining tests, 173 in number, were dry.

It is interesting and perhaps significant that about half (630) of the wells drilled in western Kansas were drilled by the independent operators. Among the large companies, the Cities Service Oil Co. drilled 163 wells; the Stanolind Oil and Gas Co., 52; the Skelly Oil Co., 39; the Continental Oil Co., 48; and the Shell Petroleum Co., 21 wells. In eastern Kansas the independent operators drilled 297 out of the total of 336 wells. Among the major oil companies the Cities Service Oil Co. drilled 19; the Phillips Petroleum Co. 7; and the Sinclair-Prairie Oil Co., 6 wells.

The figures based on relative percentages of dry holes to successful oil or gas wells are revealing. In western Kansas almost one half of all wells drilled by the independent operators were dry holes. The major oil companies drilled approximately 547 wells in western Kansas, of which 379 were successful in finding either oil or gas. It thus appears that the major companies fared better than the independents. In eastern Kansas the major companies drilled 39 wells, of which 29 were successful in finding commercial quantities of oil or of gas.

No less than 329 wildcat test holes were put down in western Kansas and 105 in eastern Kansas, or 434 in all, during 1942. Considerably more than half of these were drilled by independent operators; 223 in western and 99 in eastern Kansas. An exploratory hole ½ mile or more from production is regarded as a wildcat well in Kansas. On a percentage basis, about 80 per cent of wildcat wells were failures. In western Kansas only 20 per cent found either oil or gas. The failures were about equally distributed among the major

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TABLE 1.—*Producing Oil and Gas Fields in Kansas in 1942*

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
	OIL FIELDS									
				BARRELS	BARRELS					
	Barber County									
1	Bear Creek, 30-31-15W	Dec. 1942	40	None	None	1	Douglas	4,235	5	Sandstone
2	Lake City, 7-31-13W	July 1937	160	24,338	79,584	1	Viola	4,435	5	Limestone
						1	Simpson	4,530	11	Sandstone
						1	Arbuckle	4,607	4	Dolomite
3	Medicine Lodge, 15-33-13W	Mar. 1937	80	None	45,703	2	Misener	4,845	2	Limestone
4	Skinner, 21-31-14W	Sept. 1941	40	None	None	1	Viola	4,531	5	Limestone
5	Sun City, 35-30-15W	Dec. 1941	80	37,970	37,970	2	Lans. K. C.	4,344	11	Limestone
6	Whelan, 32-13-11W	Aug. 1934	700	198,231	700,688	1	Elgin	3,313	10	Sandstone
						18	Chat	4,355	29	Chert
	Barton County									
7	Ainsworth, 26-16-13W	Dec. 1936	5,000	514,027	2,622,220	1	Oread	2,925	4	Limestone
						62	Arbuckle	3,390	5	Dolomite
8	Ainsworth W., 5-17-13W	Aug. 1941	40	8,711	12,551	1	Arbuckle	3,358	3	Dolomite
9	Albert, 30-18-15W	Jan. 1935	1,600	137,422	797,955	16	Reagan	3,601	5	Sandstone
10	Beaver, 16-16-12W	Dec. 1934	1,200	317,067	1,300,660	6	Oread	2,900	6	Limestone
						25	Arbuckle	3,348	3	Dolomite
						1	Reagan	3,335	6	Sandstone
11	Beaver N., 4-16-12W	Oct. 1937	160	25,982	234,940	3	Arbuckle	3,316	10	Dolomite
12	Beaver NW., 6-16-12W	Nov. 1942	40	908	908	1	Lans. K. C.	3,066	20	Limestone
13	Breford SW., 23-17-11W	Apr. 1942	40	3,280	3,280	1	Arbuckle	3,311	9	Dolomite
14	Bird, 33-18-15W	Mar. 1940	40	3,335	9,450	1	Reagan	3,508	2	Sandstone
15	Bloomer, 36-17-11W	Feb. 1936	4,600	2,486,669	11,319,795	32	Lans. K. C.	3,044	10	Limestone
						1	Sooy	3,310		Conglom.
						189	Arbuckle	3,257	24	Dolomite
16	Davidson, 4-16-11W	Mar. 1938	300	74,310	140,810	2	Lans. K. C.	3,016	4	Limestone
						2	Sooy	3,317	21	Conglom.
						4	Arbuckle	3,314	26	Dolomite
17	Eberhardt, 14-19-11W	June 1935	320	115,175	343,475	1	Lans. K. C.	3,094	6	Limestone
						7	Arbuckle	3,311	49	Dolomite
18	Ellinwood N., 33-19-11W	July 1937	80	6,100	50,900	1	Arbuckle	3,328	22	Dolomite
19	Feist, 29-18-11W	Mar. 1936	40	2,824	53,680	1	Arbuckle	3,430	3	Dolomite
20	Feltes, 14-16-12	Nov. 1939	600	173,355	424,830	13	Sooy	3,342	2	Conglom.
						1	Arbuckle	3,350	4	Dolomite
21	Hagan, 20-20-11W	Dec. 1938	80	38,520	69,580	4	Arbuckle	3,323	7	Dolomite
22	Hammer, 35-19-12W	Aug. 1940	40	930	8,980	1	Arbuckle	3,348	22	Dolomite
23	Harrison, 18-20-13W	Dec. 1942	40	None	None	1	Arbuckle	3,498	5	Dolomite
24	Harzman, 33-16-11W	Oct. 1939	400			10	Lans. K. C.	3,124	8	Lime
25	Heiser, 16-19-14W	Aug. 1935	40	2,890	25,390	1	Lans. K. C.	3,228	25	Limestone
26	Hiss, 31-20-13W	Feb. 1936	200	48,810	337,910	5	Lans. K. C.	3,270	20	Limestone
27	Hoisington, 21-17-13W	Jan. 1938	160	28,910	112,010	1	Lans. K. C.	3,222	5	Limestone
						2	Arbuckle	3,440	12	Dolomite
28	Kowalsky, 32-20-11	Dec. 1941	40	2,234	2,234	1	Arbuckle	3,378	8	Dolomite
29	Kraft-Prusa, 10-17-11W	Mar. 1937	7,000	3,867,000	5,544,660	127	Arbuckle	3,281	8	Dolomite
						2	Reagan	3,310	5	Sandstone
30	Krier, 30-16-11W	Oct. 1939	1,000	295,640	548,040	2	Topeka	2,845		Limestone
						6	Shawnee	2,885		Limestone
						7	Lans. K. C.	3,030		Limestone
						11	Sooy	3,327		Conglom.
						2	Arbuckle	3,330		Dolomite
31	Lanterman, 15-19-11W	Jan. 1935	400	111,540	426,940	7	Lans. K. C.	3,109	6	Limestone
						4	Arbuckle	3,232	3	Dolomite
32	Merten, 10-19-15W	June 1942	160	7,260	7,260	4	Reagan	3,551	6	Sandstone
33	Odin, 10-17-12W	May 1938	80	3,590	18,030	1	Arbuckle	3,340	2	Dolomite
34	Pawnee Rock E., 17-20-15	Nov. 1941	80	7,440	9,060	1	Arbuckle	3,814	5	Dolomite
35	Pospishel, 20-17-15W	June 1939	80	85	15,585	1	Arbuckle	3,548	9	Dolomite
36	Mue-Tam, 35-20-11W	June 1942	40	4,800	4,800	1	Arbuckle	3,312	6	Dolomite
37	Rick, 1-19-11W	Aug. 1936	400	89,490	345,960	7	Lans. K. C.	3,106	18	Limestone
						2	Arbuckle	3,355	2	Dolomite
38	Silica, 12-20-11W	Oct. 1931	32,000	8,167,000	44,914,900	12	Lans. K. C.	2,955	95	Limestone
						783	Arbuckle	3,328	19	Dolomite
39	Straub, 36-18-11W	July 1934	40	4,471	8,710	1	Lans. K. C.	3,122	10	Limestone
40	Trapp. See Russell County, line 312.									
41	Augusta N., 28-27-4E	Jan. 1914	1,280	116,280	13,559,632	65	Bronson	1,900	35	Limestone
							Layton	2,000	15	Sandstone
							Wilcox	2,380	10	Sandstone
							Arbuckle	2,410	5	Dolomite

TABLE 1.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
42	Augusta S., 21-28-4E....	Jan. 1916	9,000	285,480	34,092,080	144	Bronson	1,900	10	Limestone
							Ft. Scott	2,100	5	Limestone
							Wilcox	2,445	10	Sandstone
							Arbuckle	2,600	5	Dolomite
43	Bausinger, 24-27-3E....	July 1929	200	5,400		4	Wilcox	3,050	29	Sandstone
44	Benton, 10-26-3E........	Jan. 1925	80	3,960		2	Chat	2,765	5	Chert
45	Blankenship, 2-26-8E....	Jan. 1921	1,200	78,120		87	Bartlesville	2,650	50	Sandstone
46	Brandt, 15-28-7E.......	June 1936	800	161,280	807,226	43	Chat	2,692	8	Chert
47	DeMoss, 5-28-7E.......	Oct. 1924	500	100,000		21	Bart.	2,700		Sandstone
							Burgess	2,732	10	
48	Douglass, 2-29-4E.......	Jan. 1916	2,500	73,080		37	Lans. K. C.	1,790	40	Lime
							Varner	2,835	50	
49	Dunns Mill, 32-29-4E...	June 1942	40	1,123	1,123	1	Arbuckle	2,951	6	Dolomite
50	Eckels, 7-27-7E.........	Aug. 1940	120	6,874	25,554	3				
51	Elbing, 8-23-4E.........	Aug. 1918	1,800	302,040		74	Lans. K. C.	2,330	70	Limestone
							Viola	2,530	40	
52	El Dorado, 29-25-5E....	Jan. 1917	25,000	2,528,810	182,427,990	1,562	Admire	600	10	Sandstone
							Lans. K. C.	1,700	20	Limestone
							Viola	2,500	5	Limestone
							Simpson	2,510	15	Sandstone
							Arbuckle	2,550	5	Dolomite
53	Ferrell, 28-28-8E........	Mar. 1939	180	57,543	140,793	8	Mis. Lime	2,647	42	Limestone
54	Fox Bush, 25-28-5E.....	Jan. 1917	5,000	112,320		121	Bartlesville	2,730	40	Sandstone
55	Garden, 32-26-6E.......	Mar. 1928	1,600	57,240		31	Bartlesville	2,760	10	Sandstone
56	Gelwich, 6-27-4E........	Apr. 1930	100	19,080		3	Viola	2,924	2	Limestone
57	Haverhill, (15-34)-27-5E.	Apr. 1927	800	148,680	3,476,680	67	Bartlesville	2,700	50	Sandstone
58	Keighley, (14-33)-27-7E.	Jan. 1925	1,800	63,000		51	Bartlesville	2,650	50	Sandstone
						3	Hunton	3,148	10	Limestone
59	Kramer-Stern, 4-28-6E..	Jan. 1928	1,100	115,920		37	Viola	3,050	3	Limestone
							Wilcox	3,020	15	Sandstone
							Arbuckle	3,040	5	Dolomite
60	Leon, 19-27-6E.........	Oct. 1926	500	23,040		20	Chat	2,660	50	Chert
							Viola	3,050		Limestone
61	McCullough, 1-28-6E....	Feb. 1926	400	27,940	421,829	8	Wilcox	3,169	6	Sandstone
62	Potwin, 36-24-3E.......	Jan. 1921	4,000	234,000		91	Bronson	2,550	5	Limestone
							Mis. Lime	2,660	95	Limestone
63	Shaffer, 4-27-6E........	June 1926	1,000	93,960		27	Mis. Lime	2,760	10	Limestone
							Viola	3,125	25	Limestone
64	Seward, 14-27-7E.......		600	12,240	971,800	14	Bartlesville	2,650	50	Sandstone
65	Smock-Sluss, 19-26-6E...	Mar. 1918	1,500	59,760		43	Bartlesville	2,685	30	Sandstone
							Viola	3,000		
66	Snowden-McSweeney, 2-29-6E..............	1930	160	2,880		1	Mis. Lime	2,833	12	Limestone
67	Steinhoff, 21-29-6E......	Jan. 1926	160	4,320		3	Chat	2,803	5	Chert
68	Vandenburg, 35-27-6E...	Dec. 1942	40	None	None	1	Bronson	2,122	5	Limestone
69	Weaver, 1-28-5E........	Jan. 1929	400	4,680		5	Bartlesville	2,690		Sandstone
70	Young, 27-26-7E........	1919	900	70,920		31	Kans. City	2,190	5	Lime
							Chat	2,650	50	Chert
	Clark County									
71	Morrison, 17-32-21W....	Oct. 1936	160	10,755	135,455	2	Viola	6,467	4	Limestone
	Coffey County									
72	Van Noy, (1-14)-23-14E, (6-18)-23-15E		700	24,480		35	Peru	1,138	12	Sandstone
							Chat	1,623	6	Chert
	Cowley County									
73	Baird, 16-34-3E.........		160	3,240		2	Bartlesville	3,260		Sandstone
74	Baird E., 15-34-3E	July 1940	40	2,411	7,361	1	Bartlesville	3,265	15	Sandstone
75	Biddle, 12-32-4E........		600	38,160		22	Stalnaker	2,300	20	Sandstone
							Kans. City	2,600	10	Limestone
76	Brown, 13-31-7E........	Sept. 1922	40	2,466	205,366	1				
77	Burden, 22-31-6E.......	Jan. 1926	1,200	49,300		32	Bartlesville	2,865	35	Sandstone
78	Carson, 19-32-3E.......	Oct. 1924	400	55,108	3,167,666	16	Layton	2,600		Sandstone
							Arbuckle	3,450		Dolomite
79	Clarke, 6-31-4E.........	Jan. 1914	180	14,400		4	Bartlesville	2,840	14	Sandstone
80	Clover, 17-31-7E........	Sept. 1940	40	1,422	5,772	1				
81	Couch, 13-30-5E........	May 1937	400	190,943	388,443	19	Burbank	2,835	5	Sandstone
82	Countryman, 4-33-7E....		600	7,560		4	Layton	1,950	12	Sandstone
83	Darien, 33-30-4E........	June 1939	200	55,792	170,278	6	Arbuckle	3,286	1	Dolomite
84	David, 35-30-4E........	July 1935	900	88,400	652,055	24	Bartlesville	2,935	40	Sandstone
85	David S., 11-31-4E, 2-31-4	Jan. 1934	200	10,212	102,062	5	Bartlesville	3,010	19	Sandstone
						1	Arbuckle	3,463	3	Dolomite
86	Deichman, 24-31-4E.....	Dec. 1941	40	28,489	28,489	1	Bartlesville	2,835	1	Sandstone
87	Dexter, 24-33-6E........	Jan. 1903	1,200	3,960		1	Mis. Lime	2,750	5	Limestone
88	Dunbar, 29-30-5E.......	Sept. 1938	40	732	7,552	1	Bronson	2,229	36	Limestone

TABLE I.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
89	Eastman, 31-30-6E	Jan. 1924	1,200	55,880	2,435,004	33	Bartlesville	2,770	100	Sandstone
90	Falls City, 17-35-7E	Jan. 1916	600	14,276	1,197,352	8	Stalnaker	2,000	12	Sandstone
91	Ferguson W., 21-30-8E	Oct. 1934	200	12,240		10	Bronson	2,181	5	Limestone
92	Frog Hollow, 20-32-5E	Jan. 1937	900	374,706	1,071,762	44	Bartlesville	3,089	8	Sandstone
93	Frog Hollow E., 15-31-5E	Apr. 1941	120	26,745	32,285	4	Bartlesville	3,060	8	Sandstone
94	Geuda Springs, 8-34-3E	May 1936	600	96,617	316,567	12 1	Bartlesville Chat	 3,320	 7	Sandstone Chert
95	Gibson, 29-34-3E	Feb. 1941	200	47,459	62,789	6	Bartlesville	3,360	14	Sandstone
96	Graham, 9-33-3E	June 1924	800	23,040	2,514,380	9	Layton Arbuckle	2,550 3,500	15 5	 Dolomite
97	Grand Summit, 10-31-8E	July 21, 1926	600	21,240		13	Bronson	1,913	19	Limestone
98	Hanna, 4-30-8E	Dec. 1936	80	2,160	7,350	2				
99	Henderson, 26-32-3E-	Apr. 1942	80	5,316	5,316	1	Bronson Arbuckle	2,694 3,419	9 4	Lime Dolomite
100	Hittle, 21-31-4E	Jan. 1926	2,400	819,000	4,018,300	73	Stalnaker Arbuckle	2,400 3,280	 8	 Dolomite
101	Hower, 32-33-3E	Dec. 1935	80	8,079	25,553	2				
102	Mahannah, 6-30-8E	1918	80	7,560	44,480	2	Burgess	2,730	9	Conglom.
103	Murphy, 8-35-3E	Jan. 1933	600	26,640		12	Chat	3,300	5	Chert
104	Olsen, 1-35-7E	Apr. 1921	300	3,960		4	Ft. Scott	2,400	4	Limestone
105	Rahn, 13-34-5E	Oct. 1939	40	18,257	34,487	2	Bartlesville	2,915	30	Sandstone
106	Rainbow Bend, 20-33-3E	Dec. 1923	2,000	285,618	13,614,164	115	Burgess	3,200	50	Sandstone
107	Reidy, 31-31-8E		160	1,800		3	Bronson	1,950	10	Limestone
108	Rock, 15-30-4E	Jan. 1923	500	50,760	1,567,560	27	Bartlesville	2,760	45	Sandstone
109	Rock W., 16-30-4E	Oct. 1937	200	101,255	511,934	12	Bartlesville	2,784	18	Sandstone
110	Rock N., 3-30-4E	Sept. 1937	200	11,114	76,137	5	Bartlesville	2,807	21	Sandstone
111	Smith, 10-31-3E	Jan. 1917	600	4,320		8	Bartlesville	3,050	19	Sandstone
112	State, 15-32-4E	Jan. 1926	1,500	46,800		25	Layton Arbuckle	2,300 3,500	12 5	Sandstone Dolomite
113	Trees, 19-30-4E	Jan. 1934	300	30,600		10	Bartlesville	2,975	25	Sandstone
114	Turner, 30-32-6E	June 1937	240	18,827	185,825	5	Layton	2,332	15	Sandstone
115	Udall, 28-30-3E		40	2,542	53,002	1				
116	Wethered, 28-31-3E	July 1935	1,000	141,346	2,198,746	1 2 2 25	Stalnaker Lans. K. C. Mis. Lime Arbuckle	 2,455 3,065 3,400	 12 8 5	 Limestone Limestone Dolomite
117	Winfield, 36-32-4E	Nov. 1914	5,000	74,880		60	Admire Peacock Layton Bartlesville Arbuckle	600 1,400 2,300 3,050 3,300	10 15 20 12 5	Sandstone Sandstone Sandstone Sandstone Dolomite
	Elk County									
118	Batesman	July 1941	40	None	None	1	Bronson	1,096	2	Limestone
119	Bush-Denton, 3-30-9E	1921	900	34,560		33 10	Stalnaker Burgess	1,060 2,297	10 5	Sandstone Conglom.
120	Collyer, 25-30-10E	Mar. 1924	300	16,560		8	Ft. Scott	1,518	10	Limestone
121	Dory, 19-30-9E	July 1921	120	3,600		3	Mis. Lime	2,470	32	Limestone
122	Dunkelberger, 27-29-10E	Sept. 1920	600	40,680		15 5	Bronson Mis. Lime	1,358 1,970	10 39	Limestone Limestone
123	Ferguson E., 23-30-8E	1921	100	2,100		1 2	Bronson Arbuckle	2,100		Limestone
124	Key, 26-31-10E	1928	250			7	Bronson Ft. Scott Arbuckle	1,270 1,624	14 4 5	Limestone Limestone Dolomite
125	Mills, 23-30-10E	Apr. 1927	160	2,880		4	Mis. Lime	2,035	10	Limestone
126	Moline, 3-31-10E	Dec. 1927	5,000	12,240		16	Encill. Mis. Lm.	1,150 1,980	12 18	Sandstone Limestone
127	Oliver, 35-31-10E	Apr. 1926	120	1,440		2 1	Ft. Scott Arbuckle	1,686	14	Limestone
128	Porter, 12-29-8E	Mar. 1923	360	19,440		8 3	Bronson Arbuckle	2,045	10 4	Limestone Dolomite
129	Rettig, 19-31-10E	Jan. 1926	40			1	Bronson	1,524	13	Limestone
130	Sellars, 11-31-9E	July 1937	80		15,721	2	Mis. Lime	2,300	22	Limestone
131	Severy, 16-28-11E	Mar. 1922	2,000	42,480		47	Bronson	1,159	13	Limestone
132	Walker, 5-31-10E	July 1927	120	2,300		2 1	Bronson Mis. Lime	1,568 2,008	10 15	Limestone Limestone
133	Webb, 28-31-10E	Oct. 1924	3,600	101,680		92	Encill. Red Ft. Scott Arbuckle	110 1,350 1,650 2,286		Sandstone Sandstone Limestone Dolomite
134	Youngmeyer, 25-28-8E	Aug. 1941	80	3,880	8,444	2	Arbuckle	2,913	4	Dolomite
	Ellis County									
135	Bemis-Shutts, 16-11-17W	Oct. 1935	12,000	5,298,245	21,242,945	401	Arbuckle	3,380	2	Dolomite
136	Bemis S., 2-12-17W	Dec. 1938	40	19,806	35,606	1	Arbuckle	3,592	11	Dolomite

TABLE I.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
137	Blue Hill, 14-12-16W	Aug. 1937	700	172,970	547,420	3 14 1	Topeka Lans. K. C. Wilcox	3,030 3,072 3,391	 33 1	Limestone Limestone Sandstone
138	Burnett, 1-11-18W	Sept. 1937	5,000	3,982,230	9,428,230	2 207	Lans. K. C. Arbuckle	3,350 3,570	8 4	Limestone Dolomite
139	Catherine, 3-13-17W	June 1936	160	7,350	131,050	2	Lans. K. C.	3,262	88	Limestone
140	Ellis, 31-12-20W	Dec. 1942	40	None	None	1	Arbuckle	3,832	7	Dolomite
141	Emmeram, 4-13-16W	June 1937	160	40,739	105,305	4	Lans. K. C.	3,260	7	Limestone
142	Hadley, 20-11-17W	Aug. 1929	40	None	58,562	2	Lans. K. C.	3,428	12	Limestone
143	Haller, 10-11-18W	July 1936	40	1,750	15,610	1	Topeka	3,036	9	Limestone
144	Herzog, 30-13-16W	June 1940	120	47,280	95,420	3	Arbuckle	3,450	8	Dolomite
145	High Spot, 28-12-16	Feb. 1941	40	2,216	4,910	1	Arbuckle	3,620	6	Limestone
146	Koblitz, 23-12-18W	Feb. 1937	800	84,533	217,240	8	Arbuckle	3,694	4	Dolomite
147	Kraus, 22-14-9W	July 1936	100	5,015	63,915	2	Sooy	3,735	5	Conglom.
148	Kraus N.W., 17-14-19W	Oct. 1942	40	None	None	1	Gorham	3,798	4	Sandstone
149	Marshall, 36-11-18W	Nov. 1936	1,000	246,490	900,240	24	Arbuckle	3,638	12	Dolomite
150	Penny Wahn, 13-15-20W	Sept. 1936	40	7,115	41,215	1	Sooy	3,653	3	Conglom.
151	Richards, 5-11-18W	Jan. 1938	120	13,085	94,235	2	Lans. K. C.	3,332	41	Limestone
152	Ruder, 17-15-18W	Aug. 1935	700	52,110	745,060	12 2	Lans. K. C. Arbuckle	3,422 3,572	18 10	Limestone Dolomite
153	Solomon, 28-11-19W	June 1936	160	22,562	101,362	3	Arbuckle	3,629	3	Dolomite
154	Sugar Loaf, 17-13-17	Mar. 1941	80	14,950	25,275	2	Arbuckle	3,645	9	Dolomite
155	Sugar Loaf SE., 28-13-17W	Sept. 1941	40	8,570	11,505	1	Lans. K. C.	3,312	8	Limestone
156	Toulon, 3-14-17W	Dec. 1935	200	22,687	196,587	4 1	Lans. K. C. Arbuckle	3,298 3,512	5 48	Limestone Dolomite
157	Ubert, 12-13-18W	Nov. 1936	160	22,067	177,117	5	Arbuckle	3,707		Dolomite
158	Walters, 2-12-18W	May 1936	1,400	528,860	1,927,410	1 39	Topeka Arbuckle	3,160 3,619	5 	Limestone Dolomite
	Ellsworth County									
159	Breford, 7-17-10W	Sept. 1932	1,200	280,030	1,539,980	8 20	Lans. K. C. Arbuckle	3,140 3,368	12 27	Limestone Dolomite
160	Heiken, 25-17-10	Oct. 1930	320		31,370	2	Arbuckle	3,269	2	Dolomite
161	Heiken N., 24-17-10W	Feb. 1942	40	None	None	1	Arbuckle	3,216	2	Dolomite
162	Lorraine, 13-17-9W	Nov. 1934	5,500	452,175	8,741,125	30 55	Lans. K. C. Arbuckle	3,060 3,200	140 5	Limestone Dolomite
163	Stoltenberg, 22-16-10W	June 1931	6,200	1,887,553	8,494,775	171	Arbuckle	3,333	14	Dolomite
164	Stoltenberg SW., 20-16-10W	July 1940	320	14,590	30,060	2	Arbuckle	3,349	7	Dolomite
165	Wilkins, 13-17-10W	Apr. 1934	3,600	801,593	2,268,900	63	Arbuckle	3,260	20	Dolomite
166	Wilkins SE., 32-17-9W	July 1942	120	19,985	19,985	3	Arbuckle	3,220	9	Dolomite
	Finney County									
167	Nunn, 27-21-34W	June 1938	800	30,650	145,605	2	Mis. Lime	4,654	10	Limestone
	Graham County									
168	Gettysburgh, 7-8-23W	Sept. 1941	40	7,898	8,915	1	Lans. K. C.	3,725	30	Limestone
169	Morel, 15-9-21W	Apr. 1938	2,400	292,370	518,670	15	Arbuckle	3,718		Dolomite
170	Penokee, 11-8-24W	Nov. 1940	40	16,560	28,810	1	Lans. K. C.	3,750	6	Limestone
	Greenwood County									
171	Atyeo-Pixlee, 6-22-10E	Jan. 1923	1,000	110,060		92	Bartlesville	2,327	50	Sandstone
172	Beaumont, 25-27-8E			182,000		19				
173	Blackwell, 16-24-13E	Jan. 1923	1,000	2,880		3	Mis. Lime	2,327		Limestone
174	Brinegar, 32-26-13E		500	5,760		27				
175	Browning, 8-22-10E	Jan. 1924	3,800	146,520		91	Bartlesville	2,314	76	Sandstone
176	Burkett, 13-23-10E	Jan. 1924	2,700	90,360		102	Bartlesville	2,000	100	Sandstone
177	Christy, 36-24-12E		2,200	5,760		4	Bartlesville	1,500	75	Sandstone
178	DeMalorie-Souder, 19-21-10E	Jan. 1924	4,500	315,360		125	Bartlesville	2,150	55	Sandstone
179	Dunaway, 4-22-13E		1,000	51,120		48	Mis. Lime	1,800	12	Limestone
180	Eureka, 35-25-10E	Jan. 1920	1,200			11	Mis. Lime	2,000	10	Limestone
181	Fankhouser, 32-21-12E	Jan. 1926	2,500	56,160		63	Bartlesville	1,750	45	Sandstone
182	Gaffney, 6-24-11E	Aug. 1926	500	10,734	256,234	3				
183	Hamilton, 26-23-11E	Jan. 1929	3,000	127,800		89	Bartlesville	1,765	72	Sandstone
184	Hinchman, 17-24-13E		200	10,080		11	Mis. Lime	1,600	50	Limestone
185	Keller, 22-26-13E	Apr. 1941	250	7,964	20,464	7				
186	Lamont, 5-22-12E	Jan. 1927	2,600	111,600		109	Bartlesville	1,650	55	Sandstone
187	Madison, 1-22-11E	Jan. 1921	3,000	154,440		103	Bartlesville	1,800	60	Sandstone
188	Polhamus, 27-24-9E	Jan. 1922	1,400	27,360		44	Bartlesville	2,170	48	Sandstone
189	Quincy, 18-25-14E	Jan. 1926	3,600	151,920		107	Bartlesville	1,420	52	Sandstone
190	Reece, 21-26-9E		1,500	47,520		28	Mis. Lime	2,100	12	Limestone
191	Sallyards, 17-25-9E	Jan. 1921	8,000	120,240		133	Bartlesville	2,350	150	Sandstone
192	Scott, 19-23-9E	Jan. 1925	2,500	97,920		71	Bartlesville	2,525	75	Sandstone
193	Seeley-Wick, 22-22-11E	Jan. 1922	7,000	324,000		329	Bartlesville	1,930	45	Sandstone
194	Smith-Jobe, 10-24-13E	Sept. 1938	40	700		1	Mis. Lime	1,662	3	Limestone

TABLE I.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
195	Teeter, 36-22-9E........	Jan. 1922	4,000	248,760		194	Bartlesville	2,400	150	Sandstone
196	Teichgraber, 2-25-8E....		900	20,160		18	Bartlesville	2,450	50	Sandstone
197	Thrall, 28-23-10E.......	1921	7,000	279,360		253	Bartlesville	2,190	166	Sandstone
198	Virgil, 13-24-12E........	Jan. 1916	4,800	99,360		100	Bartlesville Burgess Mis. Lime	1,550 1,700 1,700	40 10 12	Sandstone Conglom. Limestone
199	Virgil N., 3-23-13E......		8,000	416,160		278	Bartlesville Mis. Lime	1,550 1,700	52 12	Sandstone Limestone
200	Wiggins, 7-24-11E.......	Jan. 1925	2,500	42,480		45	Bartlesville	1,860	15	Sandstone
201	Wilkerson, 6-25-9E......		1,300	12,600		13	Bartlesville	2,300	48	Sandstone
202	Willard, 7-27-11E.......		1,000	6,480		4				
	Harvey County									
203	Halstead, 36-22-2W.....	Apr. 1929	1,200	296,285	1,388,135	20	Chat	3,005	30	Chert
204	Hollow-Nikkel, 30-22-3W	Dec. 1931	1,500	351,043	19,135,850	86	Lans. K. C. Chat Hunton Simpson Arbuckle	2,499 3,195 3,507 3,500	21 13 2 14	Limestone Chert Limestone Sandstone
205	Sperling, 23-22-2W....	Jan. 1935	500	50,646	391,300	8	Hunton Simpson	3,279 3,447	66 16	Limestone Sandstone
	Kearny County									
206	Patterson, 23-22-38W...	Aug. 1941	120	32,143	40,270	3	Patterson	4,748	4	Sandstone
	Kingman County									
207	Cunningham, 30-27-10W	Jan. 1931	1,400	726,692	3,445,395	78 7	Lans. K. C. Viola	3,390 3,925	74 33	Limestone Limestone
	Marion County									
208	Covert-Sellers, 1-21-4E..	Sept. 1920	2,400	41,760		16	Viola	2,330	5	Limestone
209	Florence, 20-21-5E......	Dec. 1929	3,000	32,400		16	Viola	2,300	10	Limestone
210	Hillsboro, 12-19-2E......	Oct. 1927	300	51,600	1,873,084	9	Viola	2,800	12	Limestone
211	Lost Springs, 22-17-4E..	Sept. 1926	2,400	810,360	4,373,507	117	Chat	2,365	16	Chert
212	Lost Springs E., 35-17-4E	Feb. 1942	40	986	986	1	Chat	2,381	21	Chert
213	Peabody, 5-22-4E.......	Sept. 1929	3,000	34,200		16	Viola	2,532	7	Limestone
	McPherson County									
214	Bitikofer, 1-20-1W......	May 1940	80	12,710	21,070	2	Chat	2,885	24	Chert
215	Bornholdt, 30-20-5W....	Aug. 1937	2,600	1,769,800	4,378,300	151	Chat	3,292	43	Chert
216	Canton N., 28-18-1W....	July 1936	80	14,417	82,885	2	Chat	2,803	29	Chert
217	Chindberg, 18-19-2W....	Jan. 1929	700	72,375	1,380,685	5 22	Lans. K. C. Chat	2,363 3,007	19 14	Limestone Chert
218	Crowther, 26-17-1W.....	Aug. 1942	250	4,250	4,250	5	Chat	2,778	12	Chert
219	Graber, 32-21-1W	May 1934	2,800	938,022	6,943,050	2 130	Misener Hunton	3,323 3,274	3 24	Sandstone Limestone
220	Henne, 21-17-1W.......	Nov. 1940	450	141,310	168,630	13	Chat	2,658	4	Chert
221	Johnson, 35-19-3W......	Feb. 1932	1,200	90,565	2,718,430	15	Chat	3,032	14	Chert
222	Lindsborg, 8-17-3W.....	Jan. 1938		207,468	273,100	33 9	Viola Simpson	3,352 3,371	21 11	Limestone Sandstone
223	Lindsborg SW., 25-17-4W	Nov. 1942	320	630	630	5	Viola	3,470	21	Limestone
224	McPherson, 29-18-2W...	Sept. 1926	2,000	48,790	973,525	25	Lans. K. C. Chat Viola	2,340 2,967 3,140	55 11 6	Limestone Chert Limestone
225	Ritz-Canton, 1-20-2W...	July 1929	13,000	1,151,852	36,057,425	236	Lans. K. C. Chat Viola Simpson	2,360 2,935 3,412 3,440	39 31 2 4	Limestone Chert Limestone Sandstone
226	Roxbury, 18-17-1W......	Nov. 1938	500	419,540	930,792	37	Chat	2,684	5	Chert
227	Roxbury S., 30-17-1W...	Oct. 1942	80	9,025	9,025	2	Chat	2,658	7	Chert
228	Voshell, 9-21-3W........	Aug. 1929	3,500	532,739	24,065,007	97	Chat Viola Simpson Arbuckle	3,095 3,301 3,322 3,394	15 3 3 10	Chert Limestone Sandstone Dolomite
	Ness County									
229	Aldrich, 7-18-25W.......	Oct. 1929	2,000	153,994	509,650	12	Mis. Lime	4,428	2	Limestone
	Norton County									
230	Hewitt, 11-4-21W.......	July 1941	40	7,261	10,968	1	Lans. K. C.	3,404	3	Limestone
	Pawnee County									
231	Pawnee Rock, 13-20-16W....	Sept. 1936	2,400	325,434	636,596	26	Arbuckle	3,825	16	Dolomite
232	Zook, 16-23-16W........	Dec. 1941	80	6,120	6,120	2	Arbuckle	4,066	8	Dolomite
	Phillips County									
233	Bow Creek, 25-5-18W...	May 1939	40	4,750	22,225	1	Lans. K. C.	3,111	53	Limestone
234	Dayton, 36-2-19W......	June 1941	1,200	129,689	136,775	2	Lans. K. C.	3,430	8	Limestone
235	Ray, 32-5-20W.........	Aug. 1940	2,400	749,025	944,225	8	Arbuckle	3,575	5	Dolomite
						55	Lamotte	3,540	13	Sandstone
	Pratt County									
236	Cairo, 7-28-11W.......	Dec. 1939	160	22,342	62,460	4	Viola	4,267	16	Limestone
237	Carmi, 29-26-12W.......	Dec. 1942	40	None	None	1	Arbuckle	4,271	4	Dolomite

TABLE I.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
238	Iuka, 11-27-13W	Aug. 1937	1,200	87,217	221,785	18 1	Simpson Arbuckle	4,292 4,354	7 13	Dolomite Dolomite
	Reno County									
239	Abbyville, 24-24-8W	Jan. 1927	1,200	48,757	457,385	9	Lans. K. C.	3,540	9	Limestone
240	Buhler, 25-22-5W	Apr. 1938	500	29,481	394,440	1 9	Viola Simpson	3,890 3,897	19 5	Limestone Sandstone
241	Burrton, 23-23-4W	Feb. 1931	5,000	2,087,503	35,180,610	351 58	Chat Hunton	3,266 3,583	42 6	Chert Limestone
242	Hilger, 16-26-4W	Mar. 1934	600	335,631	2,373,190	32	Viola	4,062	5	Limestone
243	Lerado, 11-26-9W	Dec. 1935	1,800	140,440	2,488,910	1	Lans. K. C.	3,535	4	Limestone
244	Morton, 17-24-8W	Feb. 1942	40	5,205	5,205	1	Lans. K. C.	3,180	12	Limestone
244*a*	Peace Creek, 21-23-10W	July 1941	5,000	891,379	964,595	32 130	Viola Viola	4,128 3,773	28 3	Limestone Limestone
245	Yoder, 34-24-5W	Oct. 1935	500	4,825	77,295	5	Chat	3,450	51	Chert
	Rice County									
246	Bowman, 21-19-10W	July 1936	160	56,143	77,934	4 2	Lans. K. C. Arbuckle	3,032	10	Limestone
247	Brandenstein, 10-19-10W	Nov. 1933	160	15,772	390,023	2	Lans. K. C.	3,014	12	Limestone
248	Bredfeldt W., 12-18-10W	Dec. 1939	80	6,485	30,810	2	Arbuckle	3,260	8	Dolomite
249	Chase, 32-19-9W	Mar. 1931	7,500	3,744,629	26,157,370	22 358	Lans. K. C. Arbuckle	2,942 3,246	12 38	Limestone Dolomite
250	Doran, 13-19-10W	Sept. 1936	250	38,636	173,150	6	Arbuckle	3,291	20	Dolomite
251	Edwards, 3-18-8W	Jan. 1936	2,600	1,013,087	3,973,685	91	Arbuckle	3,278	5	Dolomite
252	Geneseo, 25-18-8W	May 1934	5,600	2,763,300	9,791,500	1 193	Simpson Arbuckle	3,191 3,231	14 40	Sandstone Dolomite
253	Guldner, 16-18-9W	July 1935	160	7,306	254,995	2	Lans. K. C.	2,884	41	Limestone
254	Haferman, 6-19-9W	June 1936	800	76,332	577,220	1 10	Lans. K. C. Arbuckle	2,810 3,192	10 24	Limestone Dolomite
255	Heins, 8-18-10W	July 1938	80	11,958	51,510	1 1	Lans. K. C. Arbuckle	3,000 3,254	19 14	Limestone Dolomite
256	Karber, 7-19-10W	Oct. 1940	120	19,745	47,175	4	Arbuckle	3,343	7	Dolomite
257	Keesling, 10-20-9W	Apr. 1935	1,200	735,264	3,748,680	65	Arbuckle	3,239	26	Dolomite
258	Lyons, 14-20-8W	Nov. 1939	40	678	10,915	1	Simpson	3,280	4	Dolomite
259	Orth, 27-18-10W	July 1932	1,000	119,870	890,832	1 1 13	Shawnee Lans. K. C. Pre-Cam.	 2,915 3,240	 21 3	 Limestone Quartzite
260	Pioneer, 25-19-10W	July 1942	40	3,450	3,450	1	Arbuckle	3,281	5	Dolomite
261	Ploog, 33-18-9W	June 1930	300	71,675	1,313,045	10	Arbuckle	3,252	19	Dolomite
262	Ponce, 28-21-7W	Apr. 1936	40	3,608	32,945	1	Sooy	3,388	40	Conglom.
263	Raymond, 21-20-10W	June 1929	1,200	746,877	7,002,780	25 43	Lans. K. C. Arbuckle	3,130 3,330	10 21	Limestone Dolomite
264	Rickard, 22-18-9W	Oct. 1935	160	19,885	85,645	4	Arbuckle	3,324	41	Dolomite
265	Smyers, 36-19-6W	Feb. 1942	1,000	133,072	133,072	22	Chat	3,339	25	Chert
266	Welch, 2-21-6W	Apr. 1924	1,500	74,280	4,368,130	24	Chat	3,370	44	Chert
267	Welch E., 1-21-6W	Oct. 1941	40	6,835	6,835	1	Chat	3,341	5	Chert
268	Welch N., 23-20-6W	June 1937	160	6,085	51,045	3	Chat	3,334	32	Chert
269	Wenke, 7-20-10W	Mar. 1935	400	133,308	415,030	11	Arbuckle	3,360	13	Dolomite
270	Wenke W., 18-20-10W	Oct. 1938	80	17,354	61,920	2	Arbuckle	3,292	5	Dolomite
271	Wherry, 11-21-7W	Sept. 1933	7,200	790,035	8,516,495	165	Sooy	3,358	22	Conglom.
	Rooks County									
272	Barry, 11-9-19W	Oct. 1941	40	None	None	1	Arbuckle	3,435	7	Dolomite
273	Baum, 10-10-19W	Mar. 1941	40	2,450	2,450	1	Lans. K. C.	3,057	15	Limestone
274	Dopita, 31-8-17W	April 1934	160	64,100	221,370	2 8	Lans. K. C. Arbuckle	3,212 3,409	5 10	Limestone Dolomite
275	Dorr, 20-9-16W	Aug. 1941	40	3,342	3,342	1	Lans. K. C.	3,230	21	Limestone
276	Erway, 2-10-16W	Aug. 1941	40	7,873	10,590	1	Lans. K. C.	3,136	40	Limestone
277	Faubin, 12-6-18W	Feb. 1936	80	2,410	44,610	1	Lans. K. C.	3,128	22	Limestone
278	Kruse, 3-10-16W	Jan. 1928	40	1,000	11,900	1	Lans. K. C.	3,115	6	Limestone
279	Laton, 11-9-16W	July 1927	1,200	632,274	1,726,270	82	Lans. K. C.	3,228	33	Limestone
280	Ray SE., 9-6-20W	Dec. 1941	40	8,364	8,364	1	Reagan	3,600	5	Sandstone
281	Webster, 21-8-19W	Oct. 1930	40	6,122	56,369	1	Arbuckle	3,434	1	Dolomite
282	Westhusin, 11-9-17W	Nov. 1936	400	130,132	524,695	14	Lans. K. C.	3,231	11	Limestone
283	Zurich, 26-10-19W	Sept. 1934	200	10,406	128,455	2	Lans. K. C.	3,340	9	Limestone
	Rush County									
284	Otis, 10-18-16W	July 1934	800	351,298	1,906,695	22	Lamotte	3,527	9	Sandstone
285	Winget, 15-16-16W	Dec. 1936	120	1,571	49,000	3 1	Lans. K. C. Arbuckle	3,243 3,537	4 8	Limestone Dolomite
	Russell County									
286	Atherton, 30-13-14W	July 1935	1,800	183,346	1,281,410	8 28	Lans. K. C. Arbuckle	3,008 3,284	47 5	Limestone Dolomite
287	Big Creek, 36-14-15W	July 1935	2,600	1,456,952	3,356,235	12 40 23	Lans. K. C. Gorham Arbuckle	2,908 3,152 3,171	42 5 5	Limestone Sandstone Dolomite

TABLE I.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
288	Big Creek E., 31-14-14W	July 1938	300	98,048	301,095	7	Lans. K. C.	3,180	15	Limestone
						4	Arbuckle	3,149	4	Dolomite
289	Boxberger, 36-15-15W	Dec. 1935	160	16,325	154,795	3	Lans. K. C.	3,147	4	Limestone
290	Bunker Hill, 31-13-12W	Oct. 1935	200	3,498	73,760	4	Lans. K. C.	2,965	16	Limestone
291	Donovan, 10-15-15W	Feb. 1935	200	32,564	82,790	4	Lans. K. C.	3,193	7	Limestone
292	Driscoll, 30-15-11W	June 1940	80	8,645	24,095	1	Arbuckle	3,255	5	Dolomite
293	Dubuque, 34-15-12W	Oct. 1935	300	51,263	231,140	1	Lans. K. C.			
						5	Arbuckle	3,275	3	Dolomite
294	Eichman, 34-15-13W	May 1935	800	30,230	679,195	10	Arbuckle	3,316	10	Dolomite
295	Fairfield, 22-15-13W	Dec. 1938	40	1,949	10,130	1	Arbuckle	3,352	5	Dolomite
296	Fairfield N., 16-15-13W	Jan. 1939	400			2	Lans. K. C.	3,112	5	Limestone
						8	Arbuckle	3,232	4	Dolomite
297	Fairport, 8-12-15W	Nov. 1923	3,600	613,093	15,629,040	147	Lans. K. C.	2,950	12	Limestone
							Gorham	3,211	5	Sandstone
298	Forest Hill, 29-15-12W	July 1941	250	50,129	58,425	5	Arbuckle	3,320	3	Dolomite
299	Gideon, 8-15-14W	June 1930	40	1,995	42,495	1	Sooy	3,266	7	Conglom.
300	Gorham, 5-14-15W	Oct. 1926	8,000	2,700,127	22,160,675	1	Tarkio	2,525	25	Limestone
						10	Topeka	2,765	15	Limestone
						140	Lans. K. C.	3,027	30	Limestone
						2	Arbuckle	3,289	4	Dolomite
						156	Lamotte	3,299	1	Sandstone
301	Greenvale, 4-15-12W	Apr. 1938	2,000	528,505	905,105	19	Lans. K. C.	3,040	5	Limestone
						22	Arbuckle	3,267	21	Dolomite
302	Gustason, 14-15-12W	July 1941	80	11,961	14,295	2	Gorham	3,206	5	Sandstone
						2	Arbuckle	3,344	1	Dolomite
						2	Wabaunsee			Sandstone
303	Hall-Gurney, 30-14-13W	Oct. 1931	20,000	4,069,872	13,586,570	3	Topeka	2,675		Limestone
						396	Lans. K. C.	2,985	15	Limestone
						24	Gorham	2,965	4	Sandstone
						8	Arbuckle	3,451	3	Dolomite
						12	Lamotte	3,129	1	Sandstone
						3	Pre-Cam.	3,156	25	Granite
304	Jerry, 4-15-14W	Dec. 1942	40	None	None	1	Lans. K. C.	2,985	20	Limestone
305	Karst, 27-15-14W	Oct. 1935	160	22,815	221,065	5	Arbuckle	3,315	4	Dolomite
306	Lewis, 28-14-12W	Sept. 1940	40	1,535	8,685	1	Wabaunsee	2,317	12	Limestone
307	Mahoney, 8-14-12W	June 1940	120	7,290	31,690	3	Lans. K. C.	2,977	3	Limestone
308	Mohl, 18-14-13W	Oct. 1941	40	3,670	3,670	1	Reagan	3,253	5	Sandstone
309	Rusch, 29-14-14W	June 1941	240	63,647	94,310	2	Lans. K. C.	3,071	12	Limestone
310	Russell, 22-13-14W	Feb. 1934	1,200	425,829	5,236,575	4	Arbuckle	3,216	8	Dolomite
						3	Lans. K. C.	3,195	9	Limestone
						47	Arbuckle	3,280	6	Dolomite
311	Russell N., 15-13-14N	Oct. 1942	40	3,128	3,128	1	Lans. K. C.	2,978	30	Limestone
312	Sellens, 26-15-13W	July 1929	1,200	182,017	2,760,640	1	Shawnee			
						8	Lans. K. C.	3,088	9	Limestone
						17	Arbuckle	3,352	13	Dolomite
313	Steinert, 21-15-15W	Mar. 1936	40			1	Lans. K. C.	3,060	36	Limestone
314	Trapp, 23-15-14W	Oct. 1939	28,600	9,759,104	35,220,910	4	Topeka	2,889	7	Limestone
						124	Lans. K. C.	3,062	2	Limestone
						1	Sooy			Conglom.
						746	Arbuckle	3,252	3	Dolomite
315	Vaughn, 17-14-14W	Apr. 1937	1,000	322,020	1,329,890	24	Lans. K. C.	3,004	30	Limestone
						1	Gorham	3,282	7	Sandstone
						4	Arbuckle			Dolomite
316	Williamson, 9-14-14W	Feb. 1936	160	5,772	58,595	2	Tarkio	2,522	28	Limestone
317	Witt, 3-14-14W	Aug. 1942	80	8,060	8,060	2	Lans. K. C.	3,009	22	Limestone
	Scott County									
318	Shallow Water, 15-20-33W	Dec. 1934	600	112,942	1,152,560	9	Mis. Lime	4,670	16	Limestone
	Sedgwick County									
319	Cross, 29-25-1W	Apr. 1929	160	1,140	51,171	2	Lans. K. C.	2,690	40	Limestone
320	Eastborough, 19-29-2E	Aug. 1929	1,000			42	Chat	2,956	14	Chert
							Viola	3,238	4	Limestone
321	Eastborough N., 8-27-2E	Aug. 1938	80			1	Viola	3,258	4	Limestone
322	Goodrich, 16-25-1E	Dec. 1928	640	286,762	3,197,362	34	Lans. K. C.	2,614	2	Limestone
							Chat	3,010	10	Chert
							Misener	3,334	3	Limestone
323	Greenwich, 14-26-2E	May 1929	700	218,690	9,525,850	42	Chat	2,885	3	Chert
							Viola	3,321	5	Limestone
							Simpson	3,350	4	Sandstone
324	Kuske, 24-25-1E	Jan. 1929	40	1,990	141,680	1	Sooy	3,489	2	Conglom.
325	Oatville, 18-28-1E	Nov. 1937	80	None	11,590	1	Simpson	3,489	2	Sandstone
326	Robbins, 20-28-1E	June 1929	420	81,253	3,040,800	52	Mis. Lime	3,090	12	Limestone
327	Valley Center, 1-26-1W	Aug. 1928	1,500	81,253	20,554,525	66	Misener	3,368	7	Limestone
							Viola	3,366	2	Limestone

TABLE 1.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production In 1942	Production Cumulative	Number Wells Producing	Producing Horizon Name	Producing Horizon To Top, Ft.	Producing Horizon Thickness, Ft.	Character
	Stafford County									
328	Ahnert, 26-22-13W	June 1941	40	8,573	14,490	1	Arbuckle	3,748	4	Dolomite
329	Bedford, 21-23-12W	Aug. 1940	850	293,056	474,985	22	Arbuckle	3,839	9	Dolomite
330	Curtis, 6-22-13W	Nov. 1942	40	3,205	3,205	1	Arbuckle	3,693	7	Dolomite
331	Drach, 12-22-13W	Nov. 1937	1,100	107,327	414,505	16	Arbuckle	3,693	12	Dolomite
332	Fischer, 31-21-12W	May 1938	120	28,926	140,840	3	Arbuckle	3,641	7	Dolomite
333	Gates, 27-21-13	May 1933	640	122,882	811,800	11	Arbuckle	3,679	39	Dolomite
334	Hazel, 21-21-13W	July 1942	40	14,795	14,795	2	Arbuckle	3,692	9	Dolomite
335	Jordan, 15-25-14W	Nov. 1936	260	100,025	360,402	7	Lans. K. C.	3,722	5	Limestone
336	Kipp, 27-25-14W	Jan. 1937	220	81,980	226,980	8	Lans. K. C.	3,827	79	Limestone
337	Leesburgh, 12-25-13W	Apr. 1938	500	288,967	576,350	13	Arbuckle	4,153	10	Dolomite
338	Macksville, 3-24-15W	Mar. 1941	80	11,054	26,460	2	Lans. K. C.	3,811	16	Limestone
339	Max, 35-21-12W	Aug. 1938	400	127,517	250,950	1 10	Lans. K. C. Arbuckle	3,356 3,570	16 5	Limestone Dolomite
340	Mueller, 29-21-12	Mar. 1938	80	*	*	2	Arbuckle	3,594	7	Dolomite*
341	Rattlesnake, 13-24-14W	Oct. 1938	40	12,142	42,290	1	Lans. K. C.	3,608	48	Limestone
342	Richardson, 36-22-12W	Oct. 1930	1,200	658,069	5,057,135	60	Arbuckle	3,537	62	Dolomite
343	Riley, 28-23-11W	Aug. 1940	40	12,454	24,415	1	Lans. K. C.	3,471	5	Limestone
344	Shaeffer, 3-21-13W	Mar. 1941	300	74,710	124,250	6 1	Lans. K. C. Arbuckle	3,404 3,546	4 4	Limestone Dolomite
345	St. John, 23-24-13W	Apr. 1935	1,200	309,112	1,264,980	14 10	Lans. K. C. Arbuckle	3,588 4,075	32 12	Limestone Dolomite
346	Sittner, 33-21-12	Aug. 1937	600	219,103	399,925	2 6	Lans. K. C. Arbuckle	3,278 3,600	36 6	Limestone Dolomite
347	Sittner S., 3-22-12W	May 1938	500	214,965	575,440	18	Arbuckle	3,594	6	Dolomite
348	Snider, 3-21-11W	April 1936	320	23,930	222,200	4 2 2	Lans. K. C. Simpson Arbuckle	3,111 3,362 3,324	38 6 18	Limestone Sandstone Dolomite
349	Snider S., 16-21-11W	Aug. 1938	360	91,791	222,940	8	Simpson Arbuckle	3,402	7	Dolomite
350	Stafford, 15-24-12W	Aug. 1940	600	398,620	604,870	18 1	Viola Arbuckle	3,836 3,945	14 10	Limestone Dolomite
351	Zenith, 23-24-11W	Sept. 1937	5,400	3,584,524	10,346,250	310	Misener Viola	3,804 3,860	20 5	Sandstone Limestone
	Sumner County									
352	Anness, 2-30-4E	Oct. 1937	40	9,592	53,890	1	Simpson	4,394	7	Sandstone
353	Caldwell, 17-35-3W	May 1929	200	65,000	1,081,725	4	Simpson	4,765	19	Sandstone
354	Churchill, 25-31-2E	July 1926	1,000	140,293	18,616,250	59	Stalnaker	1,820	25	Sandstone
355	Latta, 9-30-2W	June 1927	300	84,000		12	Lans. K. C.	3,042	14	Limestone
356	Oxford, 23-32-2E	Aug. 1927	800	200,790	14,690,665	13 6 21	Stalnaker Layton Arbuckle	2,020 2,890	16 14 3	Sandstone Sandstone Dolomite
357	Oxford W., 17-32-2E	May 1926	160	13,521	512,895	3	Arbuckle			Dolomite
358	Padgett, 23-34-2E	Oct. 1924	1,800	81,360	2,000,698	20	Chat	3,474	28	Chert
359	Rainbow Bend W., 24-33-2E.		160	10,800	410,800	2	Burbank Arbuckle		18 5	Sandstone Dolomite
360	Rutter, 21-33-2E	July 1926	40	9,999	67,840	2	Chat	3,315	27	Chert
361	Vernon N., 15-35-2E	July 1915	400			9	Chat	3,443	22	Chert
362	Wellington, 33-31-1W	Dec. 1929	1,200	243,078	5,057,780	98	Chat	3,655	11	Chert
363	Zyba, 7-30-1E	Nov. 1937	80	8,411	26,365	2	Simpson	3,866	3	Sandstone
	Trego County									
364	Ogallah, 10-12-21W	Nov. 1941	40	None	None	1	Arbuckle	3,992	5	Dolomite
365	Wakeeney, 14-11-23W	Oct. 1934	640	43,725	471,220	7	Lans. K. C.	3,619	8	Limestone
	Woodson County									
366	Big Sandy, 14-26-14E	1926	800	7,560		20	Burbank	1,200	50	Sandstone
367	Hoagland, 2-24-14E	Mar. 1925	700	8,110		18	Mis. Lime	1,620	37	Limestone
368	Wiede, 32-23-15E	Mar. 1922	400	4,320		7	Mis. Lime	1,531	10	Limestone
369	Winterscheid, 15-23-14E		7,700	212,400		222	Bartlesville Mis. Lime	1,575	15	Limestone

GAS FIELDS

Line Number	County, Field and Location	Discovery Date	Area, Acres	In 1942	Cumulative	Number Wells Producing	Name	To Top, Ft.	Thickness, Ft.	Character
				M Cu. Ft.	M Cu. Ft.					
	Barber County									
1	Medicine Lodge, 13-33-13W	Jan. 1927	5,000	9,905,548	61,111,128	33	Chat	4,455	10	Chert
	Edwards County									
2	McCarty, 31-25-17W	May 1929	400	23,138		1	Sooy	4,545	10	Conglom.
	Harvey County									
3	Hollow-Nikkel	Dec. 1931	1,500	56,504		12	Chat	3,295	15	Chert
4	Sperling, 23-22-2W	Jan. 1935	600	24,001	6,217,795	2	Chat	2,955	50	Chert

* Production included with Sittner.

TABLE 1.—(*Continued*)

Line Number	County, Field and Location	Discovery Date	Area, Acres	Production		Number Wells Producing	Producing Horizon			Character
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	
	Jefferson County									
5	McLouth................	Nov. 1939		4,438,867		24 1	McLouth Mis. Lime	1,426 1,475	45 4	Sandstone Limestone
6	*McPherson County*..........			1,848,975						
	Pratt County									
7	Cairo, 7-28-11W.........	Nov. 1935	20,000	12,596,156	51,051,517	39	Viola	4,278	8	Limestone
8	Stark, 18-26-11W........	Apr. 1941	160	None	None	1	Viola	4,121	2	Limestone
9	Ward, 11-26-12W........	Dec. 1941	160	None	None	1	Viola	4,107	15	Limestone
	Reno County									
10	Burrton, 23-23-4W......	Sept. 1930	5,000	3,876,450	50,007,578	52	Chat	3,298	70	Chert
11	Yoder, 34-24-5W.........	Oct. 1936	800	519,163		4	Chat	3,402	50	Chert
	Rice County									
12	Lyons, 35-19-8W.........	July 1888	1,500	564,981	10,994,224	1 11	Simpson Arbuckle	3,290 3,277	7 10	Dolomite Dolomite
13	Orth, 27-18-10W.........	July 1933	640	494,973		3	Lans. K. C.	2,906	30	Limestone
14	Thurber, 22-21-9W......	Oct. 1937	400	3,265,357	8,225,247	7	Misener	3,317	10	Conglom.
	Rush County									
15	Otis, 11-18-16W.........	Mar. 1930	15,000	11,065,286	74,189,523	60	Lamotte	3,507	2	Sandstone
	Stafford County									
16	Hitz, 4-24-12W..........	Oct. 1941	40	None	None	1	Maquoketa	3,800	12	Dolomite
	Sumner County									
17	Wellington, 33-31-1W....	Dec. 1929	1,200	496,163		97	Chat	3,655	12	Chert
	Southwest Kansas									
18	Hugoton, 3-35-34W.....	1922	2 million	41,418,093	299,919,168	327	Winfield Ft. Riley Florence	2,755 2,800 2,850	10 8 10	Limestone Limestone Limestone

TABLE 2.—*Summary of Drilling Operations in Kansas*

Important Wildcats Drilled in 1942

	County	Location			Total Depth, Ft.	Deepest Horizon Tested	Drilled by	Remarks
		Sec.	Tp.	Rge.				
1	Comanche..............................	27	33	19 W	6,525	Arbuckle	Sinclair	Dry
2	Decatur................................	32	3	28 W	4,400	Arbuckle	Phillips	Dry
3	Graham.................................	11	6	21 W	3,790	Arbuckle	Helmerick and Payne	Dry
4	Harper.................................	1	34	6 W	5,128	Arbuckle	Williams	Dry
5	Kiowa..................................	23	28	16 W	5,025	Arbuckle	Herndon	Dry
6	Saline.................................	23	13	2 W	3,320	Arbuckle	Auto Ordnance	Dry
7	Saline.................................	32	14	2 W	3,470	Arbuckle	Adkins	Dry
8	Saline.................................	30	15	2 W	3,605	Arbuckle	Cohen	Dry
9	Saline.................................	34	15	3 W	3,530	Arbuckle	Appleman	Dry
10	Saline.................................	28	16	3 W	3,570	Arbuckle	Appleman	Dry
11	Sherman................................	28	10	40 W	5,913	Arbuckle	Sinclair	Dry
12	Thomas.................................	27	8	32 W	4,652	Kansas City	Billings	Dry
13	Wallace................................	22	11	39 W	4,094		Sinclair	Dry

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942....................................		
Number of oil wells completed during 1942................................	771	29
Number of gas wells completed during 1942...............................	83	2
Number of dry holes completed during 1942................................	628	

companies and the independent companies, the percentage for the former being 80 per cent and for the latter 85 per cent. In eastern Kansas the percentage of failures ran slightly lower, at 82 per cent, the proportions between major and independent companies being about the same.

Exploratory wells drilled at a distance of 2 miles or more from any known pool or well are generally referred to as "rank wildcat" wells. Classified in this manner, 202 of all wildcat wells in western Kansas fall into such a category. Of this number 14 were successful in uncovering new oil or gas reserves. Put on a percentage basis, these figures reveal that less than 10 per cent of the rank wildcats were able to open up new reserves. In eastern Kansas

TABLE 3.—*New Pools Discovered in Kansas in* 1942

	County, Field and Location	Operator and Fee	Geologic Formation	Depth, Ft.	Month	Initial Production
		OIL				
	Barber County					BARRELS
1	Bear Creek, 30-31-15W	Great Lakes Carbon No. 1 Welsh	Douglas	4,235–4,249	Dec.	50
	Barton County					
2	Merten, 10-19-15W	Appleman No. 1 Merten	Reagan	3,562–3,565	June	168
3	Breford SW., 23-17-11W	Auto Ordnance No. 1A Disque	Arbuckle	3,315–3,320	Apr.	307
4	Mue-Tam 35-20-11W	Lario No. 1 Mueller	Arbuckle	3,312–3,315	June	354
5	Beaver NW., 6-16-12W	Appleman No. 1 Stull	Lans. K. C.	3,066–3,074	Nov.	408
6	Harrison, 18-20-13W	Palmer and Mid-Cont. No. 1 Harrison	Arbuckle	3,520–3,528	Dec.	80
	Butler County					
7	Dunns Mill 32-29-4E	Deep Rock No. 1 Eckels	Arbuckle	2,951–2,956	Nov.	320
8	Vandenburg, 35-27-6E	J. J. Lynn No. 1 Vandenburg	Lans. K. C.	2,122–2,127	Dec.	100
	Cowley County					
9	Henderson 26-32-3E	Wakefield No. 1 Henderson	Lans. K. C.	2,694–2,704	Apr.	160
	Ellis County					
10	Kraus NW., 17-14-19W	Pryor and Lockhart No. 1 Kraus	Gorham	3,798–3,806	Oct.	50
11	Ellis 31-12-20W	Darby No. 1 Huber	Arbuckle	3,832–3,840	Dec.	337
	Ellsworth County					
12	Heiken N. 24-17-10W	Appleman No. 1 Stratman	Arbuckle	3,216–3,218	Feb.	230
13	Wilkens SE., 32-17-9W	Mid-Plains No. 1 Alden	Arbuckle	3,220–3,233	July	3,000
	Harvey County					
14	Stucky, 3-23-3W	Williams No. 1 Stucky	Mis. Lime	3,258–3,261	Dec.	8
	McPherson County					
15	Crowther, 26-17-1W	Westgate Greenland No. 1 Crowther	Chat	2,778–2,794	Aug.	150
16	Lindsborg SW., 25-17-4W	Globe No. 1 No. 1 Bean	Viola	3,401–3,407	Nov.	3,000
17	Roxbury S., 30-17-1W	Westgate Greenland No. 1 Lilly	Chat	2,656–2,668	Oct.	3,000
	Pratt County					
18	Carmi, 29-26-12W	Hollow No. 1 "B" Brown	Arbuckle	4,271–4,281	Dec.	200
	Rice County					
19	Smyers, 36-19-6W	Nelson Drilling No. 1 Smyers	Chat	3,343–3,345	Feb.	3,000
20	Pioneer, 25-19-10W	Harwood No. 1 Proffitt	Arbuckle	3,281–3,290	July	560
	Reno County					
21	Morton, 17-24-8W	Cities Service No. 1 Morton	Lans. K. C.	3,438–3,450	Feb.	185
	Rooks County					
22	Baum, 10-10-16W	Palmer Oil Co No. 1 Baum	Lans. K. C.	3,057–3,065	Mar.	210
23	Barry, 11-9-19W	Continental No. 1 Barry	Arbuckle	3,450–3,456	Oct.	3,000
24	Dorr, 20-9-16W	Cities Service No. 1 Dorr	Lans. K. C.	3,188–3,205	Aug.	140
	Russell County					
25	Jerry, 4-15-14 W	Appleman No. 1 Driscoll	Lans. K. C.	2,985–2,991	Dec.	460
26	Russell N., 15-13-14W	Aylward No. 1 Ehrlich	Lans. K. C.	2,995–3,002	Oct.	430
27	Witt, 3-14-14W	Witt No. 1 Witt	Lans. K. C.	3,009–3,011	Aug.	430
	Stafford County					
28	Curtis, 6-22-13W	Vickers No. 1 Curtis	Arbuckle	3,693–3,700	Nov.	3,000
29	Hazel, 21-21-13W	Faulkner No. 1 Ward	Arbuckle	3,692–3,703	July	2,400
		GAS				
	Barber County					MILLION CU. FT.
30	Deerhead, 26-32-15W	Champlin No. 1 Hildebrand	Viola	4,931–4,941	March	14
	Edwards County					
31	Belpre, 8-25-16W	Cities Service No. 1 English	Lans. K. C.	3,807–3,815	Oct.	25
	Jefferson County					
32	Auckerland, 1-10-20E	Mosbacher No. 1 Bell	Bartlesville	1,343–1,368	June	6

34 wells can be classified as rank wildcats. Two of these, or 14 per cent, were successful in finding new oil pools. In summary, it appears that about three out of four ordinary wildcat tests find dry holes and that among the rank wildcats nine out of ten will be failures.

PRODUCTION

Oil.—Kansas reached an all-time high production record during 1942. From 22,620 wells approximately 97,845,000 bbl. of oil was produced—an increase of 18 per cent over the previous year. This notable increase was made possible by the favorable location of the state with reference to consuming centers. With the disruption of tanker service along the Atlantic Seaboard much more oil was shipped to eastern consumers than in former years. Part of this went by pipe line and a great deal was shipped out by tank car. A few additional gathering lines were built in western Kansas, but in general the building of such additional transport facilities was hampered by the scarcity of materials. Outstanding pools from the production standpoint were the Trapp pool, which produced 9,759,100 bbl.; the Silica pool, of southern Rice County, which produced 8,167,000 bbl.; the Bemis-Shutts pool of northern Ellis County, which produced 5,298,245 bbl.; and the Peace Creek pool of western Reno County, which produced 891,379 barrels.

Gas.—The production of gas again established a new high record in 1942. Somewhat more than 98½ billion cubic feet of gas was marketed, the great bulk coming from the Hugoton district of southwestern Kansas. Some of the new pipe lines that had been building during 1941 were completed during 1942 and partly account for the increase.

NEW POOLS

According to the detailed list in Table 3, 29 new oil pools and 3 new gas pools were discovered in Kansas during 1942. The most valuable of these new pools is the Smyers pool in Rice County, where the Mississippian limestone is the producing zone. Since the discovery of the pool 780 acres have been proved productive and an additional area of 640 acres appears likely to produce later. The Lindsborg Southwest pool is a very promising field and may have an eventual extent of 1000 acres. It seems to be separated from the main Lindsborg pool by a shallow saddle. With the possible exception of the Merten pool, the other fields listed will probably be small or of slight potential importance. Many of them are so close to present production that they

TABLE 4.—*New Producing Horizons in Old Fields in Kansas*

	County, Field and Location	Operator and Fee	Geologic Formation	Depth, Ft.	Month	Initial Production
1	*Barber County* Whelan, 31-31-11W..................	Great Lakes No. 1 Schwartz	Elgin sand	3,313–3,323	June	4 million cu. ft.
2	*Butler County* El Dorado, 17-25-5E..................	Dustin No. 1	Chat			BARRELS
3	*Barton County* Ainsworth, 10-17-13W..............	Continental Oil No. 3 Underwood	Lans. K. C.	3,181–3,189	Mar.	340
4	*Ellis County* Haller, 10-11-18W..................	Kansas Development No. 1 Haller	Lans. K. C.			270
5	*McPherson County* Lindsborg, 8-17-3W..................	Auto Ordnance No. 1 Johnson	Simpson	3,451–3,460	July	2,250
6	*Rice County* Haferman, 5-19-9W..................	McPherson Drilling No. 1	Lans. K. C.			55
7	*Russell County* Gustason, 5-15-12W................	Stanolind No. 1 Kostrup	Lans. K. C.	3,165–3,175	Aug.	350
8	*Cowley County* Henderson, 22-32-3E................	Wakefield No. 1 Campbell	Arbuckle	3,419-3,423	Aug.	120

probably represent only extensions of previously found pools.

From the standpoint of discovery methods used to find the new pools, an examination of the record shows that one was found by using surface geology; 14 were found by subsurface geology; three were drilled on core-drill information; four are due to seismograph exploration; and nine are due to random drilling or other unknown factor. In one of the pools, the Bear Creek pool in Barber County, a new producing horizon has been found—the Douglas sandstone, which lies between the Oread limestone and the Lansing limestone.* In other areas where this horizon has been found temporarily productive it has proved of slight importance. Therefore its performance in the new area will be watched with interest.

Drilling Activity

The areas that received most attention this year are the Peace Creek pool in western Reno County and the Lindsborg pool in northern McPherson County. The Peace Creek pool was enlarged by the merging of the former Peace Creek Northeast and the Schweizer pool with the main pool. Toward the southwest, extensions have almost brought about a link with the large Zenith pool.

The Lindsborg pool has had a sensational revival this year. It is on a well-known anticlinal trend, which was first tested in December 1929 when the Dixie (now Stanolind) Oil Co. completed a 10-bbl. well on the Olsson farm, in sec. 10, T.16S., R.3W. After producing 1400 bbl. of oil it was abandoned. A second test well was drilled near by on the Thelander farm in 1937 but this test was dry except for a small show in the Viola limestone. In January of the next year the first commercial producer was drilled in the Lindsborg pool in sec. 8, T.17S., R.3W. Between that time and 1942 only two additional small producers were drilled in the pool. During 1942 the M. and L. Drilling Co. drilled several offset wells. Other operators were attracted to the district and drilling was carried on rather rapidly during the remainder of the year. Now there are 42 wells in the pool. A further interesting development in 1942 was the discovery of a second producing zone, the Simpson sandstone (Wilcox). This sandstone seems to produce on the highest part of the anticline, where the usual producing zone is not porous or absent.

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* See table of producing horizons on page 291 of volume 136, *Trans.* A.I.M.E.

Oil and Gas Development in Kentucky during 1942

By Louise Barton Freeman,* Coleman D. Hunter† and Iley B. Browning‡

During 1942, production of oil in Kentucky reached a total of 4,169,163 bbl. of which 1,807,809 bbl. came from eastern Kentucky. This was more than a million barrels less than in 1941, owing partly to the low price of crude oil, which almost eliminated wildcatting, and partly to spacing regulations, which limited the number of wells drilled in small, shallow pools where the pressures are not sufficient to maintain maximum recovery in widely spaced wells.

In eastern Kentucky much of the oil was produced from outliers of the Mauch Chunk series at the disconformable contact of the Mississippian and Pennsylvanian. Although wells producing from this horizon, known as the Maxon, are sprinkled over the entire area, the greatest concentrations are in Martin, Floyd, Knott and Pike Counties. A new 30 to 40-bbl. well has been completed in this formation in Pike County, where the carbon ratio is so high that ordinarily oil would not be expected. Pike County is one of the largest producers of Maxon gas, and the offset well to this oil well produced gas. Of the 412 gas wells drilled in Pike County, 12.2 per cent produced gas from the Maxon horizon.

During 1942, the old Menifee "Corniferous" field, the Mariba-Denniston field, was redrilled between old wells, and although it did not produce any large amount of oil it did contribute 2018 bbl. In the oldest oil field in eastern Kentucky, the Ragland pool, operators are cleaning out abandoned wells and are using this oil for fuel oil. There is a possibility that some of this may be used in the future as distilled fuel oil.

Eight wells were completed in 1942 in the Jackson County gas field. The development of Jackson County, which was started in 1934 and in which commercial quantities of gas were encountered at a depth of 1100 to 1200 ft., has become of importance in 1942 with the completion of eight wells, making a total of 24 commercial producing wells with an average rock pressure of 140 lb. At this time the gas is not being marketed. In the last year it has been found that these wells, which produce from the Niagaran dolomite ("Corniferous"), respond to acidizing and the production has been thus greatly increased.

There has been less development in Estill and Lee Counties than for several years. Two wells were drilled in Greenup County, one of which had a show of oil in the Berea sandstone. One deep test, drilled by the Owens-Libbey-Owens Co. in Lawrence County, was dry. This well was drilled to a depth of 4975 ft. into the top of the Clinton shale sequence.

Of the 202 wells completed in Floyd, Martin, Knott and Pike Counties, 187 were gas wells, 3 oil wells and 12 dry holes. In Floyd County 66 per cent of the gas production was from the Devonian-Mississippian black shales, 53 per cent in Martin, 79 per cent in Knott and 65 per cent in Pike. This is probably the largest continuous gas field east of the Mississippi

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River except that in Louisiana. There are good reserves of gas and they are being fully developed.

The first gas wells drilled to the "Big Six" (Upper Clinton) in Johnson County were completed in 1940. During 1941, nine "Big Six" tests were completed, of which only one was a dry hole. During 1942, eight wells were drilled, of which three were dry holes. This field is 2 to 5 miles west of the town of Paintsville, on the waters of Barnett's, Jenny's and Rockhouse Creeks. The areal extent of this "Big Six" gas production, which is similar to the Frozen Creek and Jackson fields of Breathitt County, has not been determined. At this date four wells are being drilled.

TABLE 1.—*Oil and Gas Production in Kentucky*

Line Number	County	Year of Discovery	Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells				
								During 1942		End of 1942	
			From 1918 to End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Producing Oil[c]	Producing Gas[c]
1	Barren	1919	2,705,645	19,296				14	11	3	
2	Breathitt	1921			y	y		4			
3	Breckinridge	1921	3,428	547				1	1		
4	Butler	1937	167,400	23,859				2	1		
5	Clay	1900			y	y	91	13	3		
6	Christian							1	1		
7	Clinton	1921	124,107	19,728			84				
8	Cumberland	1919	363,995							16	
9	Daviess	1919	10,142,794	625,396				45	29	14	2
10	Elliott	1917	103,977	4,947							
11	Estill	1918	11,732,619	393,938							
12	Floyd	1904	366,393	16,758	y	y	1,508	54	2	1	51
13	Grayson							2	2		
14	Hancock	1930	3,297,703	155,929				4	2	2	
15	Hart	1930	6,313,968	68,005				3	3	0	
16	Henderson	1931	3,176,237	257,442				54	18	36	
17	Hopkins	1920	81,296					1	1		
18	Jackson	1919	15,489				24	8			8
19	Johnson	1919	2,311,244	288,402	y	y		8	3		5
20	Knott	1906	45,733		y	y	427	40	3		37
21	Knox	1929						3			
22	Lawrence	1913	8,510,592	185,290							
23	Lee	1918	40,124,823	488,533							
24	McCreary		114,841	1,484							
25	McLean	1919	4,677,802	277,460				9	6	3	
26	Magoffin	1920	11,615,474	239,077			1,080	2	0	1	1
27	Martin	1898	447,940	57,380	y	y	449	28	2	1	25
28	Menifee	1902	240,572	2,189							
29	Metcalfe	1932	40,623	1,217				1	1	0	
30	Muhlenberg	1929	339,798	10,789							
31	Ohio	1919	22,127,022	686,969				11	8	3	
32	Owsley	1920	127,663	2,242				2		2	
33	Pike	1931	371		y	y	433	80	5	1	74
34	Powell	1918	4,557,779	131,222							
35	Union	1942	69,876	69,876				26	8	18	
36	Warren	1918	6,684,588	64,261							
37	Wayne	1898	2,174,944	32,984			200				
38	Webster	1938	52,356	25,737				4	2	2	
39	Wolfe	1912	1,194,792	18,206							
40	Total		142,053,884	4,169,163							

[b] Footnotes to column heads and explanation of symbols are given on page 264.

Ten wells were drilled in Lewis County to test the area of thinning of the "Corniferous" Niagaran dolomites in a structural position similar to that of the Big Sinking field to the south. No production was encountered although all but two of the wells had showings of oil with as much as 20 feet saturated with dead oil.

There was little activity in the northwestern section of the state, in that part of the Eastern Interior Basin lying in Kentucky, in the early part of 1942, because of the outbreak of the war and the promulgation of Order M-68 by the Federal Government, by means of which drilling of wells was limited to one in 40 acres. However, in the early summer this was altered to permit a closer spacing of

TABLE I.—(*Continued*)

Line Number	Producing Formation							Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	Corniferous	Sil		Por	450–650		MC	Lower Ordovician	2,320
2	Corniferous	Sil	DS	Por	1,725–1,875		A	Silurian	
3	Jett	MisU	S	Por				Silurian	1,785
4	Jett, McClosky	MisU	S, OL	Por	375–800		T	Devonian	2,090
5	Big Lime, Corniferous	MisU, Sil	S, D	Por	1,400–1,600	± 20	AM	Silurian	2,360
6	Bethel	MisU	S	Por					
7	Granville	Ord U	L	Por	400–500			Lower Ordovician	1,235
8	Sunnybrook	Ord U	L	Cav	400–500				
9	Jackson, Barlow, Pen, Jett, Jones, McClosky	Pen, MisU, MisL	S OL	10–14 Por	1,800–1,900				
10	Weir, Black Shale	MisL, Dev	S, H		100–800		MC	Lower Ordovician	4,191
11	Corniferous	Sil	L	15–20	100–800			Lower Ordovician	2,650
12	Pen, Maxon, Big Lime, Big Injun	Pen, MisU, MisL	S, L	Por	900–3,100		MC	Silurian	3,643
13	Corniferous	Dev, Sil	L, D	Por				Lower Ordovician	3,652
14	Jett	MisU	S	Por	400–1,300			Silurian	1,910
15	Corniferous, Blue Sand	Sil	D	Por	500–1,000		MC	Lower Ordovician	1,920
16	Pen, Waltersburg, Jett, Barlow, McClosky	Pen, MisU, MisL	S, OL	10–14	1,800-1,900			Devonian	4,700
17	McClosky	MisL	OL	20				Devonian	4,921
18	Corniferous	Sil	D	Por	1,100–1,200	± 20		Silurian	1,200
19	"Big Six"	Sil	S	Por	2,380	± 40		Silurian	2,430
20	Pen, Maxon, Big Lime, Big Injun, Black Shale	Pen, MisU, MisL, D	S, L, LS, H	Por	1,250-3,000			Upper Ordovician	3,706
21	Corniferous	Sil	D	Por	1,960			Lower Ordovician	5,000
22	Weir	MisL	S	Por	900–960			Silurian	4,975
23	Corniferous	Sil	D, DS	15–20	825-1,200	70–100		Lower Ordovician	3,527
24	Beaver, Sunnybrook	MisL, Ord	L	Por, Cav				Lower Ordovician	2,515
25	Jett, Bethel, McClosky	MisU, MisL	S, OL	12–15	340–2,050	± 20		Devonian	3,817
26	Pen, Maxon, Big Lime, Black Shale	Pen, MisU, Dev	S, L, H	Por	1,050–1,350	± 40–450		Lower Ordovician	5,070
27	Pen, Maxon, Big Lime, Black Shale	Pen, MisU, Dev	S, L, H	Por	700–3,000	10-600		Silurian	3,325
28	Corniferous	Sil	D, DS	Por	500–1,230			Ordovician	
29	Corniferous	Sil	D	Por	400–500	20–40		Lower Ordovician	1,785
30	McClosky	MisL	OL	Por	1,240–1,690	± 10		Silurian	5,065
31	Jett, Barlow, Bethel	MisU	S	12–20	585–725	15–30		Silurian	2,505
32	Big Lime	MisU	L	Por	1,100	15		Silurian	1,962
33	Pen, Maxon, Big Lime, Black Shale	Pen, MisU, Dev	S, L, LS, H	Por	800–4,000	10–800		Ordovician	5,343
34	Corniferous	Sil	D, DS	15–20	650–1,150	30		Silurian	
35	Pen, Waltersburg, McClosky	Pen, MisU	S, OL	Por	1,700–2,700			Ordovician	6,000
36	"Corniferous"	Sil	D	Por	900–1,000			Lower Ordovician	2,870
37	Beaver Stray	MisL	L	Por, Cav	400–500			Lower Ordovician	1,810
38	Jett, McClosky	MisU, MisL	S, OL	Por	1,400	12		Devonian	3,217
39	Corniferous	Sil	D, DS	Por	1,270–1,380			Lower Ordovician	3,785
40									

wells and activity was again resumed. A number of new prolific pools were discovered.

The largest of these, as now developed, is the Burbank pool, about 3 miles northwest of Smith Mills in Henderson County and approximately 12 miles from the city of Henderson. At present some 15 wells have been completed on a 20-acre pattern and the potential production is approximately 12,000 bbl. daily, although, because pipe-line facilities are lacking, the amount being taken from the field is only about 8000 bbl. per day.

Production is obtained principally from the Cypress and Aux Vases sandstone, and from the Ste. Genevieve limestone or "McClosky sand," although some production has also been found in the Tar Springs and Hardinsburg sandstones. Except for the McClosky, these are all formations of Chester or Upper Mississippian age. The completion depths range from 1900 to 2600 ft., depending upon which formation is productive. The initial production ranges from 150 to 1000 bbl. per well. Rotary drilling apparatus is used exclusively.

In Union County three new areas of production were discovered. One of these, and that in which development has been most extensive to date, is approximately 3 miles north of Morganfield. The discovery well was drilled by the Pure Oil Co. At present 8 wells have been completed, ranging from 150 to 750 bbl. initial daily production. The producing horizons are principally Aux Vases and Ste. Genevieve, although some oil is found in the Waltersburg sandstone. Drilling depths and methods are the same as at the Burbank pool.

Another new productive area of the same type as those mentioned above is just beyond the city limits of Uniontown and southeast to east of that city.

West of Morganfield, at Spring Grove, production from the basal Pennsylvanian was discovered at a depth of approximately 1400 ft. The initial production from the wells in this area ranged up to 100 bbl. daily per well. The area is comparatively small, some 8 or 10 wells covering not over 150 acres having been drilled.

Further development in the Sebree pool, southeast of Sebree in Webster County, led to the completion of two new wells, one having an initial of 50 bbl. and the other more than 500 bbl. daily. The producing formations in these wells are Ste. Genevieve and upper Aux Vases.

These wells focused attention on the south, and this has resulted in the discovery of a new pool about 3 miles west of the village of Robards, Henderson County, and a like distance northeast of the village of Poole, Webster County. In this well oil was encountered in the upper Aux Vases sandstone, sometimes called Cunningham sand, and it is estimated that the production may be 600 to 700 bbl. natural daily. The additional development in the Sebree area and the new discovery some 7 miles northwest will lead to much activity in this area during the coming year.

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Petroleum Development and Production in Louisiana during 1942

By J. Huner, Jr.*

During 1942, Louisiana attained the rank of fourth among the great oil-producing states of this country. Its present prominent position is the result of an orderly and systematic program of exploitation with emphasis on conservation.

Even before the functioning of M-68, the Federal spacing order, development and production in Louisiana were regulated by various acts of legislation, the most recent of which and by far the most effective is Act 157 of 1940. Under the authority of this act, it has been possible for the Department of Conservation to hold many public hearings and thereby to secure data and evidence regarding the feasibility of issuing rules and regulations for development of various oil and gas fields in the state. As a result of information compiled at such public hearings, many orders have been issued by the Commissioner of Conservation that have in most cases provided reasonable solutions to the problems that arise in the exploitation and development of fields in this state.

Probably one of the most effective powers granted the Commissioner of Conservation in the state of Louisiana has been the authority to provide for fieldwide unitization and pooling of condensate fields. This has led to the erection of huge cycling plants in Louisiana, which permit the most efficient recovery of the liquid content of the reservoirs, and further conserve most of the gas reserve that undoubtedly will be of considerable future value.

Many months have passed since various orders of the Department of Conservation were put into effect, and all are accomplishing their purpose; namely, the elimination of waste. Although the effectiveness of these orders provides considerable satisfaction to the members of the Department of Conservation, it is also a tribute to the members of the oil and gas industry in Louisiana, who, in addition to providing carefully prepared technical data, have also given unstinting cooperation and have thereby enabled the Department to cope intelligently with the many problems.

Production

On Dec. 31, 1942, oil and/or gas was being produced in 50 parishes, or 78 per cent of all the parishes in the state. Thirty-three of the parishes produced oil and gas, 12 produced oil, and 5 produced solely gas. This is indeed an enviable record for any state. However, it is reasonable to assume that eventually all parishes in the state of Louisiana will be productive. From a geological viewpoint, there is no apparent reason to assume otherwise—a point that all operators seeking oil and gas production in this state may well bear in mind.

Twenty new fields were found during 1942—a rate of discovery that does not compare favorably with the 30 new fields found during 1941. The record of discoveries in Louisiana during 1942 is further disappointing when it is realized that 8 of the 20 new fields discovered were gas fields. During this period of war emergency, there are, of course, many

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reasons to account for the discouraging lack of new fields found during the past year. Lack of wildcat drilling, however, seems to be one of the chief reasons.

Statewide production for 1942 was approximately 111.6 million barrels of crude oil and approximately 7.1 million barrels of condensate, or a total of 118.8 million barrels of liquid hydrocarbons.* This amounted to about 8 per cent of the total production of liquid hydrocarbons in the United States.

A comparison of production for 1941 and 1942 shows that Louisiana produced approximately the same amount during each of these years. The year 1942 showed an increase of less than one per cent over 1941.

Completions

Completion records from January to December 1942 show that 757 wells were drilled in or adjoining producing fields. These wells were drilled to deepen or extend producing areas and are not considered as wildcat wells. Of this total number, 553 were completed as oil wells and 75 as gas wells, and the remaining 129 were dry holes. This means that 83 per cent of the wells drilled were successful, compared with 76 per cent of the wells for 1941.

The majority of wells drilled during 1942 were on 40-acre units and therefore established greater reserves than did the wells the preceding year, which for the most part were completed on smaller units. Therefore, during 1942, the percentage of successful completions was not only higher than that for 1941 but such completions actually established more reserves.

A comparison of the total number of field wells drilled during 1942 with the 1512 that were drilled during 1941 indicates a decrease of 50 per cent for 1942. Because of the shortage of materials and labor for drilling wells, this decrease was to be expected. However, in spite of the decrease of actual completions, Louisiana has been able to maintain its production, thereby suggesting for the time being that if additional wells had been drilled during 1942 they would have been unnecessary. If increased production is to be demanded from Louisiana in the future, it will undoubtedly be necessary to complete more wells than are actually producing in the state at the present time. The present producing wells have, in so far as good conservation is concerned, attained their maximum daily production.

Gas Production

Production of casinghead gas in 1942 amounted to approximately 200 million M cu. ft. and natural gas to approximately 463 million M cu. ft., or a total approximate gas production of 669 million M cu. ft. These figures indicate an increase slightly in excess of 16 per cent over the total gas production for 1941. Production of natural gas increased 23 per cent over that of 1941 while casinghead gas increased 3 per cent.*

During 1942 Louisiana continued to add to its already enormous gas reserve. As already indicated, 8 of the 20 new fields found during the year were gas fields.

During the past few years, considerable effort and research have been devoted toward the utilization of natural gas for purposes other than fuel. A vast supply of derivatives available in natural gas have been developed and many are already in production. With this viewpoint in mind, it becomes imperative that wastage of gas be held to a minimum if states like Louisiana plan to participate advantageously in the very encouraging outlook for natural gas. It is not too much to expect that within the not too distant future the value of chemical derivatives of gas may equal the present value of oil production in Louisiana. Plants such as are now operating at Cotton Valley and South Jennings, and which soon will operate at Erath, already indicate the manner in which basic raw hydrocarbons will be obtained from the gas. Plants now in the various stages of operation at Baton Rouge, Lake Charles, and other towns in Louisiana indicate the manner in which these hydrocarbons, or chemical derivatives, will be fabricated into artificial rubber, high-octane aviation gasolines, plastics, and other products. At present, it is felt that the use of natural gas as a fuel, at least intrastate, is economically desirable. It may be that within the near future no gas except dry gas will be permitted to be utilized as fuel.

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* Complete figures total 119.1 million barrels of liquid hydrocarbons.

* Order 45, issued by the Department of Conservation on Nov. 10, 1942, reduced the gas-oil ratio from 4000:1 to 2000:1, and at the present rate of production will conserve in excess of 80 million cubic feet of gas per day.

New Fields, New Sands and Extensions in North Louisiana during 1942

In north Louisiana, interest has been divided during the past year between Wilcox production and production from Lower Cretaceous zones such as the Pettit. Nine new fields were found, as follows:

Field	Parish	Type of Production
Beekman	Morehouse	Gas
Big Island	Rapides	Oil
Calvin	Winn	Gas
Catahoula Lake	La Salle	Oil
Elm Ridge	La Salle	Oil
Lake End	Red River	Oil
Lake St. John	Concordia	Oil
Manifest	Catahoula	Oil
North Carterville	Bossier	Oil

The discovery well in the Beekman field was completed in the Cotton Valley formation for an initial production of 1200 M cu. ft. of gas with 33 bbl. of 42° A P.I. gravity oil. This production in the Cotton Valley formation is the first to be found in the northeastern part of the state. Subsequent to the completion of the discovery well, an additional well was drilled about one mile east of the discovery well. This test, however, proved dry and was abandoned.

The discovery well in the Big Island field was a pumper. Subsequently, two dry holes were drilled. Although production from this field is obtained from the Wilcox, it is apparent that this field is not destined to be very prolific.

The discovery well in the Calvin field was completed in the Paluxy formation with an initial production of 9500 M cu. ft. of gas and having a gas-condensate ratio of 30,000:1. This field lies between two well-known piercement salt domes; namely, Drakes Dome and Prices Dome. The relationship of these domes to the structure of the Calvin field should provide considerable information concerning the possibility of obtaining production from structures formed in areas between two closely associated salt domes. Such close association of domes is quite common in north Louisiana.

The discovery well in the Catahoula Lake field, another Wilcox field, was not very encouraging. However, the second well in the field found 25 ft. of saturated sand and extended the field ½ mile to the southwest.

The discovery well in the Elm Ridge field was completed in the Wilcox formation for an initial production of 201 bbl. of 41° A.P.I. gravity oil through a 13/64-in. choke. The gas-oil ratio was 363:1. Subsequent drilling indicates that this field will provide very little additional reserve.

The Lake End field in Red River Parish produces from the Nacatoch formation of Upper Cretaceous age. The discovery well was completed as a pumper. The field apparently is of no great significance as far as reserve is concerned.

TABLE 1.—*Oil and Gas Production in Louisiana*

Line Number	Field, *Parish*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
	NORTH LOUISIANA					
1	Ajax, *DeSoto and Natchitoches*	1941	120		4,605	995
2	Athens, *Claiborne*	1940		320+[2]	3,200[3]	638[3]
3	Bear Creek, *Bienville*	1937		4,000	80,131[3]	35,802[3]
4	Beekman, *Morehouse*	1942		320+	917	917
5	Bellevue, *Bossier*	1921	1,360	160	10,603,797	210,531
6	Benson, *DeSoto*	1928	320		6,494	0
7	Bethany, *Caddo*[1]	1916	20	2.560	3,023[4]	1,468
8	Big Island, *Rapides*	1942	40		3,828	3,828
9	Blue Lake, *Sabine*	1928	340		21,366[5]	8,470
10	Caddo (includes Hosston, Pine Island and Vivian areas), *Caddo*[1]	1905	60,000	5,000	155,431,940[6]	2,669,402
11	Calvin, *Winn*	1942		320+[2]	218[3]	218[3]
12	Carterville-Sarepta, *Bossier and Webster*	1922	4,250		2,813,688	56,603
13	Caspiana, *Caddo*	1925		400	0	0
14	Catahoula Lake, *La Salle*	1942	120+		15,302	15,302
15	Cedar Grove, *Caddo*	1915		3,840	0	0
16	Clarks, *Caldwell*	1941		160+[2]	0	0
17	Converse, *Sabine*	1932	5,760		2,411,607	121,402
18	Cotton Valley, *Webster*	1922 1926 1936 1936	2,000	12,000	38,747,868	5,389,803
19	Cypress Bayou, *La Salle*	1941	80		87,498	44,089
20	Dixie, *Caddo*	1929	1,500		32,962[7]	9,985
21	Driscoll, *Bienville*	1936		1,500	21,327	9,246
22	Elm Grove, *Bossier and Caddo*	1916	320	14,600	3,530,490	103,787
23	Elm Ridge, *La Salle*	1942	40+[2]		4,469	4,469
24	Epps, *East and West Carroll*	1928		1,280	0	0
25	Funny Louis Bayou, *La Salle*	1941		160+[2]	0	0
26	Grand Cane, *De Soto*	1941	80+		1,400	1,400
27	Greenwood, *Caddo*	1940		320	0	0
28	Grogan, *DeSoto*	1937	40		28,671	0
29	Haynesville, *Claiborne and Webster*[11]	1921	12,000		75,047,646	4,641,314
30	Holly, *DeSoto*	1930	80	160	1,034,667	36,081
31	Homer, *Claiborne*	1919	3,020		71,943,181	1,043,200
32	Indian Bayou, *LaSalle*	1941	40		35,395	35,395

[b] Footnotes to column heads and explanation of symbols are given on page 264.
[1] Extends into Texas.
[2] One well field, not defined.
[3] Condensate only.
[4] Included under Waskom prior to 1941.
[5] Included under Zwolle prior to 1941.
[6] Included Dixie and Cedar Grove prior to 1941.
[7] Included under Caddo prior to 1941.
[11] Extends into Arkansas.

TABLE I.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Repressuring Operation^d
	To End of 1942	During 1942	Completed to End of 1942	During 1942		End of 1942			Number of Wells		
				Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift	
NORTH LOUISIANA											
1	0	0	2	1	0	2	0	0	0	0	
2	238	47	1	0	0	1	0	0	0	0	
3	6,406	3,493	6	1	0	0	0	6	0	0	
4	13	13	1	1	0	0	0	1	0	0	
5	2,625	59	447	2	1	*y*	153	0	0	153	
6	107	0	5	0	0	0	0	0	0	0	
7	^{4}	0	14	0	0	0	2	0	0	2	
8	0	0	1	1	0	1	0	0	0	0	
9	0^5	0	11	0	*y*	*y*	1	0	0	1	
10	$143,834^6$	888	4,806	30	113	*y*	1,427	17	0	1,427	
11	*x*	*x*	1	1	0	1	0	0	0	0	
12	42,686	8	201	0	3	*y*	27	0	0	27	
13	193^8	0	5	0	0	0	0	0	0	0	
14	6	6	2	2	0	0	2	0	1	1	
15	^{7}	0	18	0	0	0	0	0	0	0	
16	0	0	1	0	0	1	0	0	0	0	
17	55	0	199	0	11	1	63	0	0	63	
18	252,461	70,263	454	1	6	68^9	46	39	9	37	
19	26	15	2	0	0	1	1	0	0	1	
20	^{7}	0	56	1		3	3	0	0	3	
21	13,614	2,293	4	0	0	0	0	4	0	0	
22	194,535	112	249	0	3	*y*	39	13	0	39	
23	3	3	1	1	0	0	1	0	1	0	
24	8,753	1,226	5	0	0	1	0	4	0	0	
25	0	0	1	0	0	1	0	0	0	0	
26	0	0	2	1	0	0	2	0	0	2	
27	0	0	2	0		2	0	0	0	0	
28	0	0	1	0	0	0	0	0	0	0	
29	934,604	3,078	895	127	56	*y*	381	0	126	255	
30	168	8	15	0	0	*y*	4	2	0	4	
31	7,650	473	641	1	4	*y*	319	0	0	319	
32	14	14	1	0	0	0	1	0	1	0	

[8] Included under Elm Grove prior to 1940.
[9] Includes input wells.

TABLE I.—(*Continued*)

Line Number	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
							Depth, Avg. Ft.					
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					NORTH LOUISIANA							
1	42		Paluxy	CreL	S	Por	3,209	3,214	5	D	Paluxy	3,500
2	61		Hosston	CreL	S	Por	6,166	6,176	10	DF	Hosston	6,706
3	59		Pettit	CreL	OL	16	6,605	6,780	25	D	Hosston	8,016
			Hosston	CreL	S	125	7,215	7,879	15	D		
4			Cotton Valley	Jur	S	Por	3,700	3,720	20		Eagle Mills salt	6,956
5	18–19		Nacatoch	CreU	S	Por	300	425	30	DF	Eagle Mills salt	9,070
			Rodessa	CreL	OL	Por	1,700	1,900	*x*	DU		
6			Paluxy	CreL	S	Por	3,000	3,100	10	A	Paluxy	3,440
7			Nacatoch	CreU	S	Por	930	1,150	25	A	Mooringsport	3,758
			Washita	CreL	S	Por	2,400	2,490	10	A		
			Paluxy	CreL	S	Por	2,830	3,000	10	A		
8			Wilcox	Eoc	S	Por	5,150	5,152	2		Midway	7,105
9	42–45		Chalk Series	CreU	C	Fis	2,100	2,500	*x*	T	Paluxy	4,503
10	19–21		Nacatoch	CreU	S	Por	800	1,000	30	Af	Igneous below Eagle Mills salt	11,419
	28–39		Saratoga-Annona	CreU	C	Fis	1,400	1,700	*x*	Af		
	23–44		Tokio	CreU	S	Por	2,000	2,100	20	Af		
	26–43		Paluxy	CreL	S	Por	2,300	2,600[10]	*x*	Af		
			Ferry Lake	CreL	A	Fis	2,700		*x*	Af		
			Rodessa	CreL	OL	Por	2,800	2,950[10]	*x*	Af		
	42–44		Sligo	CreL	OL	Por	3,620	3,700	*x*	Af		
			Hosston	CreL	S	Por	3,900	4,000	15	Af		
11	72		Paluxy	CreL	S	Por	5,784	5,794	10		L. Cretaceous	9,719
12	26–43		Tokio	CreU	S	Por	2,675	3,175[10]	30	A	Cotton Valley	10,070
13			Nacatoch	CreU	S	Por	800	850	20	N	Cotton Valley	9,141
			Eagleford	CreU	S	Por	2,450	2,475	8	N		
14	39–43		Wilcox	Eoc	S	Por	4,040	4,100[10]	50		Midway	5,400
15			Tokio	CreU	S	Por	2,450	2,500	25	A	Hosston	6,001
16			Wilcox	Eoc	S	Por	2,173	2,185	12	AM	Wilcox	4,006
17	38–45		Saratoga-Annona	CreU	C	Fis	1,600	2,100	*x*	Af	Hosston	8,929
	42		Paluxy	CreL	S	Por	3,604	3,426	20	Af		
18	27–30		Ozan	CreU	S	27	2,500	2,600	30	A	Cotton Valley	9,198
	51–53		Rodessa	CreL	S, L	24	3,900	4,700[10]	35	A		
	49–67		Hosston	CreL	S	17	5,500	5,800[10]	10	A		
	41–65		Cotton Valley	Jur	S	17	7,900	8,650[10]	40	A		
19	44		Wilcox	Eoc	S	22	4,750	4,765	15	AM	Midway	5,976
20	38		Paluxy	CreL	S	Por	2,400	2,475	10	T	Mooringsport	3,514
21			Rodessa	CreL	OL	16	5,860	5,885	15	D	Hosston	7,693
			Hosston	CreL	S	12	7,160	7,220	25	D		
22	29–30		Nacatoch	CreU	S	Por	800	1,000	30	A	Cotton Valley	8,647
			Ozan	CreU	S	Por	1,550	1,750	12	A		
			Tokio	CreU	S	Por	1,675	1,930[10]	50	A		
			Paluxy	CreL	S	Por	2,400	2,500	10	A		
23	41		Wilcox	Eoc	S	Por	4,572	4,585	13	AM	Midway	5,976
24			Monroe Gas Rock	CreU	C	Por	2,302	2,356	25	D	Eagleford	2,820
25			Sparta	Eoc	S	Por	1,465	1,475	10		Wilcox	4,000
26			Paluxy	CreL	S	Por	2,820	2,858	10		Paluxy	2,858
27			Paluxy	CreL	S	Por	2,549	2,606	20	AM	Paluxy	2,981
28	38–39		Paluxy	CreL	S	Por	2,929	2,934	5	D	Paluxy	2,961
29	35–36		Tokio	CreU	S	Por	2,725	2,875	25	A	Smackover	11,254
	35		Rodessa	CreL	OL	Por	4,250	4,400	20	AL		
	38–42		Sligo	CreL	OL	18	5,200	5,650	20	AL		
30	37–39		Eagleford	CreU	S	Por	2,538	2,581	11	NL	Paluxy	3,373
31	35–38		Nacatoch	CreU	S	Por	1,000	1,400	50	DF	Cotton Valley	4,504
	35–38		Tokio	CreU	S	Por	1,900	2,000	50	DF		
32	44		Wilcox	Eoc	S	Por	4,294	4,304	10	AM	Midway	5,905

[10] Range of producing sands.

TABLE 1.—(*Continued*)

Line Number	Field, *Parish*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
33	Lake Bistineau, *Bienville*	1916		5,200	25,193[3]	11,601[3]
34	Lake End, *Red River*	1942	40+		407	407
35	Lake St. John, *Concordia*	1942	400	160+	67,012	67,012
36	Larto Lake, *Catahoula*	1941	40		39,154	28,375
37	Lisbon, *Claiborne and Lincoln*	1936	8,000	1,920	9,997,293	758,012
38	Logansport, *DeSoto*[1]	1938		12,800	71,454[3]	44,316[3]
39	Longwood, *Caddo*	1926		4,560	15,465[3,4]	4,124[3]
40	Manifest, *Catahoula*	1942	40		597	597
41	Monroe, *Ouachita, Morehouse and Union*	1916		251,000	0	0
42	Nebo-Hemphill, *LaSalle*	1940	5,880		4,087,090	3,153,675
43	North Carterville, *Bossier*	1942	40+[2]		1,027	1,027
44	Northeast Lisbon, *Claiborne*	1941		640	0	0
45	Oakland, *Union*	1928	60		6,393[12]	4,287
46	Olla, *LaSalle*	1940	8,300	8,300	9,773,866	4,549,093
47	Pleasant Hill, *DeSoto and Sabine*	1927	2,000		1,494,753	26,457
48	Red River-Bull Bayou, *DeSoto and Red River*	1912	37,000	3,000	57,097,620	335,301
49	Richland, *Richland*	1926		49,280	0	0
50	Rodessa, *Caddo*[1,11]	1930	10,000	8,000	75,812,878	4,121,598
51	Ruston, *Lincoln*	1937		320	0	0
52	Shongaloo, *Webster*	1921	150	5,600	176,673	8,577
53	Shreveport, *Bossier and Caddo*	1913	2,200	6,000	5,499,300	923,155
54	Sibley, *Webster*	1936		1,000	25,297[3]	10,937[3]
55	Simsboro, *Lincoln*	1935		700	8,561[3]	3,881[3]
56	Sligo, *Bossier*	1922	2,000	13,000	3,408,827	856,465
57	South Jena, *LaSalle*	1941	600		193,527	152,923
58	Spider, *DeSoto*	1914		500	0	0
59	Spring Ridge, *Sabine*	1931	40	160	x	0
60	Standard, *LaSalle*	1940		1,000	0	0
61	Sugar Creek, *Claiborne*	1930	440	4,000	1,493,015	408,626
62	Summerville, *LaSalle*	1940	700	40	245,270	199,367
63	Sutherlin, *DeSoto*	1920		1,280	0	0
64	Trout Creek, *LaSalle*	1941	250		120,236	111,880
65	Tullos-Urania-Georgetown, *Grant, LaSalle and Winn*	1925	6,600		25,886,138	777,804
66	Waskom, *Caddo*[1]	1924		1,600	26,388[14]	4,136
67	White Sulphur Springs, *LaSalle*	1927	350		12,290	0
68	Willow Lake, *Catahoula*	1941	80		102,011	96,743
69	Zenoria-Little Creek, *LaSalle*	1938	2,680	2,680	1,778,610	1,348,720
70	Zwolle, *Sabine*	1928	28,000		14,687,093[15]	258,981

[12] No records prior to 1941.

[14] Included Bethany and Longwood prior to 1941.

[15] Included Blue Lake prior to 1941.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Repressuring Operations[d]
				During 1942		End of 1942			Number of Wells		
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	
33	33,912	11,693	28	0	0	0	0	17	0	0	
34	0	0	1	1	0	0	1	0	0	1	
35	32,676	32,676	10	10	0	1	9	0	9	0	
36	y	y	1	0	0	0	1	0	1	0	
37	19,081	4,920	273	4	31	y	145	7	0	145	
38	17,792	11,439	13	2	0	2	0	11	0	0	
39	7,987[4]	238	38	0	y	y	0	2	0	0	
40	0	0	1	1	0	0	1	0	0	1	
41	3,249,889	217,936	1,446	30	12	y	0	1,313	0	0	
42	4,677	3,379	139	62	0	4	130	5	75	55	
43	0	0	1	1	0	0	1	0	0	1	
44	0	0	2	1	0	2	0	0	0	0	
45	0	0	7	0	0	y	4	0	0	4	
46	11,103	7,649	190	0	0	8	176	6	57	119	
47	416	68	64	0	5	y	25	1	0	25	
48	68,531	964	1,441	1	26	y	105	9	0	105	
49	460,619	0	313	0	0	2	0	0	0	0	
50	463,599	45,279	504	0	10	45[13]	288	129	80	208	
51	0	0	1	0	0	1	0	0	0	0	
52	72,907	355	94	0	1	y	2	1	0	2	
53	10,619	3,377	60	4	0	2	46	0	12	34	
54	5,386	1,810	6	0	0	0	0	6	0	0	
55	9,318	1,696	2	0	0	0	0	2	0	0	
56	164,0	28,661	172	13	2	y	63	47	3	60	
57	71	71	7	0	0	2	5	0	3	2	
58	341	0	5	0	0	0	0	0	0	0	
59	0	0	2	0	0	0	0	0	0	0	
60	682	496	3	0	0	2	0	1	0	0	
61	69,801	9,826	36	5	1	0	14	20	13	1	
62	516	97	13	4	0	0	11	1	2	9	
63	224	0	4	0	0	0	0	0	0	0	
64	48	48	6	1	0	0	6	0	1	5	
65	5	0	532	3	2	y	214	0	0	214	
66	13,433[14]	1,015	32	0	2	y	0	3	0	0	
67	0	0	12	0	0	0	0	0	0	0	
68	y	y	2	0	0	0	2	0	2	0	
69	2,925	2,671	74	19	2	5	55	7	6	49	
70	180[15]	0	382	0	15	y	41	0	0	41	

[13] Includes three input wells.

TABLE 1.—(*Continued*)

Line Number	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
33			Ozan	CreU	S	Por	1,950	2,100	25	AF	Cotton Valley	8,532
			Tokio	CreU	S	Por	2,525	2,675	25	AF		
			Sligo	CreL	OL	17	5,000	5,350	40	AF		
			Cotton Valley	Jur	S	12	8,400	8,532	y	AF		
34			Nacatoch	CreU	S	Por	1,224	1,251	y	D	Hosston	7,120
35			Sparta	Eoc	S	Por	2,130	2,145	15	D	Rodessa	9,994
	34–45		Wilcox	Eoc	S	Por	3,487	4,577[10]	55	D		
36	46		Wilcox	Eoc	S	22	5,108	5,133	25		Midway	7,031
37	32–33		Sligo	CreL	OL	18	5,100	5,350	10	DL	Eagle Mills salt	12,592
	42		Hosston	CreL	S	Por	5,300	5,400	7	DL		
			Cotton Valley	Jur	S	13	8,400	8,800[10]	30	DL		
	56		Smackover	Jur	L	Por	10,150	10,400	100	D		
38			Rodessa	CreL	OL	18	4,825	5,020	50	A	Hosston	6,271
			Sligo	CreL	OL	12	5,980	6,000	20	A		
39			Nacatoch	CreU	S	Por	870	970	40	A	Hosston	6,065
			Paluxy	CreL	S	Por	2,690	2,775	20	A		
			Sligo	CreL	OL	Por	5,590	5,630	40	A		
			Hosston	CreL	S	Por	6,000	6,050	50	A		
40	20		Sparta	Eoc	S	Por	1,810	1,817	7		Wilcox	4,554
41			Monroe Gas Rock	CreU	C	Por	2,145	2,205	30	MC	Morehouse	10,475
			Second Sand	CreU	S	Por	2,265	2,430	10	MC		
42	19		Cockfield	Eoc	S	Por	1,420	1,435	15	AL	Midway	5,301
	39–43		Wilcox	Eoc	S	25	3,340	4,150[10]	400	AL		
43	39		Sligo	CreL	OL	Por	6,029	6,122	y	AL	Hosston	6,382
44			Hosston	CreL	S	Por	5,100	5,213[10]	25	NL	Hosston	6,185
45				CreU	S	Por	2,200	2,300	10		Upper Cretaceous	3,001
46	26-32		Wilcox	Eoc	S	20	2,040	2,790[10]	154	AL	Rodessa	8,997
47	40–43		Paluxy	CreL	S	Por	3,100	3,250	15	N	Mooringsport	5,063
48			Nacatoch	CreU	S	Por	725	1,000	30	AF	Hosston	6,479
			Saratoga-Annona	CreU	C	Por	850	1,050	x	AF		
			Paluxy	CreL	S	Por	2,450	3,500[10]	10	AF		
49			Tokio	CreU	S	Por	2,349	2,447	76	A	Cotton Valley	9,986
50	40–70		Rodessa	CreL	S, L, OL	15–25	5,400	6,100[10]	125	AF	Eagle Mills salt	11,486
51			Sligo	CreL	OL	Por	5,300	5,325	20	A	Hosston	5,822
52	29		Tokio	CreU	S	20	2,600	2,675	15	A	Cotton Valley	10,462
	50–65		Cotton Valley	Jur	S	10	8,850	9,200[10]	30	A		
53			Nacatoch	CreU	S	Por	875	1,025	25	A	Cotton Valley	8,690
			Tokio	CreU	S	Por	2,450	2,500	10	A		
			Sligo	CreL	OL	18	5,550	5,620	15	A		
54	58		Rodessa	CreL	OL	15	5,500	5,750	35	A	Cotton Valley	10,383
55			Rodessa	CreL	OL	17	5,280	5,292	12	D	Cotton Valley	10,002
			Hosston	CreL	S	12	6,460	6,540	25	D		
56			Nacatoch	CreU	S	Por	830	1,060	40	Df	Hosston	6,122
			Ozan	CreU	S	Por	1,600	1,800	15	Df		
			Tokio	CreU	S	Por	2,460	2,630	10	Df		
			Paluxy	CreL	S	Por	2,640	2,810	15	Df		
	41-43		Mooringsport	CreL	L	Por	3,000	3,200	10	Df		
	57		Rodessa	CreL	OL	15	4,150	4,450	30	Df		
	49		Sligo	CreL	OL	17	4,925	5,275	50	Df		
57	33–43		Wilcox	Eoc	S	26	3,272	3,776[10]	51	NL	Midway	5,062
58			Paluxy	CreL	S	Por	2,800	3,100	20	A	Hosston	6,063
59	39		Paluxy	CreL	S	Por	3,350	3,370	5	D	Mooringsport	3,723
60			Wilcox	Eoc	S	28	2,164	2,485[10]	52	NL	U. Cretaceous	5,097
61			Rodessa	CreL	OL	18	4,300	4,600	13	A	Cotton Valley	10,759
	32-37		Sligo	CreL	OL	14	4,900	5,500[10]	50	A		
	34		Hosston	CreL	S	25	5,550	5,820	18	AL		
62	28-33		Wilcox	Eoc	S	20	2,512	3,167[10]	45	NL	Midway	4,071
63			Paluxy	CreL	S	Por	2,775	2,925	10	D	Paluxy	3,003
64	35–43		Wilcox	Eoc	S	28	3,168	3,614[10]	49	NL	Midway	4,810
65	21–22		Wilcox	Eoc	S	Por	1,490	1,609	9	Nf	Tokio	6,463
66			Nacatoch	CreU	S	Por	925	1,075	30	A	Hosston	6,400
			Tokio	CreU	S	Por	1,875	2,350[10]	50	A		
			Paluxy	CreL	S	Por	2,540	2,750	30	A		
			Hosston	CreL	S	13	6,157	6,185	15	A		
67	20		Cockfield	Eoc	S	Por	794	804	9	NF	Wilcox	2,435
68	37		Wilcox	Eoc	S	Por	5,533	5,539	6		Midway	6,810
69	19–38		Wilcox	Eoc	S	28	1,612	3,590[10]	190	A	Midway	4,124
70	42		Annona	CreU	C	Fis	2,100	2,500	x	A	Rodessa	6,178

Table 1.—(*Continued*)

Line Number	Field, *Parish*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
	South Louisiana					
71	Abbeville, *Vermilion*	1937	200	955	743,925	99,726
72	Anse la Butte, *Lafayette and St. Martin*	1902	200		4,996,121	2,252,494
73	Avery Island, *Iberia*	1942	20		22,518	22,518
74	Bancroft, *Beauregard*	1938	750		3,111,653	323,320
75	Barataria, *Jefferson*	1939	270		2,511,004	1,059,337
76	Bastian Bay, *Plaquemines*	1941	120		59,966	48,505
77	Bateman Lake, *St. Mary*	1937		4,640	1,258,958	338,652
78	Bay Baptiste, *Terrebonne*	1938	Abandoned		1,320	0
79	Bay de Chene (Hackberry Bay), *Jefferson and Lafourche*	1941	40	160	36,800	36,800
80	Bayou Bleu, *Iberville*	1929	480		1,655,142	754,273
81	Bayou Bouillon, *St. Martin*	1902	40		421,762	11,304
82	Bayou Choctaw, *W. Baton Rouge and Iberville*	1931	110		3,838,608	266,386
83	Bayou Couba, *Jefferson*	1942	40		2,862	2,862
84	Bayou des Allemands, *St. Charles and Lafourche*	1937	400		630,377	247,678
85	Bayou des Glaises, *Iberville*	1940	Abandoned		3,679	0
86	Bayou Mallet, *Acadia*	1936	360		517,840	90,532
87	Bayou Pigeon, *Iberia*	1940	200		583,677	212,722
88	Bayou Sale, *St. Mary*	1941	1,280		1,086,287	944,537
89	Bay St. Elaine, *Terrebonne*	1934	180		823,510	161,164
90	Belle Isle, *St. Mary*	1941		20	4,160	2,299[3]
91	Big Lake, *Cameron*	1935	Abandoned		72,338	0
92	Black Bayou, *Cameron*	1929	300		9,639,656	924,387
93	Bosco-Cankton, *Acadia and St. Landry*	1934	1,600	640	23,334,474	1,377,807
94	Branch, *Acadia*	1942		320[2]	64,812	64,812[3]
95	Bully Camp, *Lafourche*	1942		20	0	0
96	Caillou Island, *Terrebonne*	1930	500		33,719,593	1,525,007
97	Cameron Meadows, *Cameron*	1931	300		9,142,989	680,703
98	Chacahoula, *Lafourche*	1938	260		1,970,547	617,871
99	Chalkley, *Cameron*	1938	2,000		4,370,630	1,510,258
100	Charenton, *St. Mary*	1936	750		9,792,817	1,379,894
101	Cheneyville, *Rapides*	1935	640		3,667,396	870,314
102	China, *Jefferson Davis*	1940	Abandoned		7,110	0
103	Creole, *Cameron*	1938	100		1,969,176	262,691
104	Darrow, *Ascension*	1932	175		5,490,034	520,801
105	Deer Island, *Terrebonne*	1942		320[2]	0	0
106	Delacroix Island, *Plaquemines*	1941	120		48,422	41,058
107	Delarge, *Terrebonne*	1938		640[2]	194,100	39,490[3]
108	Delta Duck Club, *Plaquemines*	1941	80		61,002	28,175
109	Delta Farms, *Jefferson and Lafourche*	1940	640		498,293	316,072
110	Dog Lake, *Terrebonne*	1935	160		2,703,150	251,825
111	East Hackberry, *Cameron*	1927	840		29,879,962	1,502,304
112	East White Lake, *Vermilion*	1940	320		298,450	217,444
113	Edgerly, *Calcasieu*	1912	215		8,508,163	92,021
114	Eola, *Avoyelles*	1939	2,100		11,911,529	3,313,913
115	Erath, *Vermilion*	1940		2,400	382,111	197,383
116	Fausse Pointe, *Iberia and St. Martin*	1926	100		169,591	56,512

TABLE I.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Repressuring Operation^d
				During 1942		End of 1942			Number of Wells		
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift	
					SOUTH LOUISIANA						
71	8,737	2,660	12	0	1	2	2	7	9	0	
72	1,855	1,094	y	4	4	4	62	0	51	11	
73	13	13	1	1	0	0	1	0	1	0	
74	15,864	2,101	43	0	y	11	26	0	11	15	
75	1,617	821	23	1	1	2	21	0	21	0	
76	579	576	3	1	0	1	2	0	2	0	
77	9,029	8,309	14	1	0	4[16]	4	6	10	0	
78	68	0	1	0	0	0	0	0	0	0	
79	301	301	2	1	0	1	1	0	1	0	
80	348	194	41	3	y	2	31	0	26	5	
81	102	0	15	0	0	1	2	0	1	1	
82	554	178	23	1	0	8	14	0	3	11	
83	0	0	1/	1	0	1	0	0	0	0	
84	2,061	859	15	6	1	5	7	1	8	0	
85	0	0	1	0	1	0	0	0	0	0	
86	1,267	152	8	0	0	0	3	2	5	0	
87	268	121	5	0	0	1	4	0	4	0	
88	1,433	1,346	24	16	0	3	21	0	21	0	
89	585	145	14	0	2	0	10	0	9	1	
90	341	187	1	0	0	0	0	1	1	0	
91	263	0	5	0	0	0	0	0	0	0	
92	1,900	578	38	5	y	8	25	0	17	8	
93	46,928	4,683	72	0	3	14	38	4	30	12	PM
94	3,772	3,772	1	1	0	0	0	1	1	0	
95	12	12	1	1	0	0	0	1	1	0	
96	2,988	982	55	1	0	1	49	0	39	10	
97	884	121	68	2	1	8	34	0	8	26	
98	1,529	544	17	4	0	1	16	0	16	0	
99	9,573	3,849	39	4	y	6	32	0	31	1	
100	3,324	278	205	2	y	17	143	0	15	128	
101	13,243	3,240	49	0	0	4	28	2	21	9	
102	822	0	1	0	1	0	0	0	0	0	
103	1,164	268	10	0	0	2	8	0	8	0	
104	2,319	202	22	0	0	2	19	0	19	0	
105	0	0	1	1	0	1	0	0	0	0	
106	180	100	2	0	0	0	1	1	2	0	
107	6,711	1,380	1	0	0	0	0	1	1	0	
108	147	103	2	0	0	0	2	0	2	0	
109	1,102	564	11	7	0	1	10	0	10	0	
110	1,091	324	17	0	1	4	9	1	9	1	
111	5,197	1,158	152	1	8	18	54	1	24	31	
112	1,161	577	10[17]	4	0	1	9	0	8	1	
113	2	0	177	0	y	0	14	0	0	14	
114	17,142	6,047	101	0	0	3	92	0	73	19	
115	1,968	1,124	11	2	0	2	0	9	9	0	
116	918	634	17	2	4	1	4	0	4	0	

[16] Includes two input wells.
[17] Two dual completions.

TABLE 1.—(*Continued*)

Line Number	Character of Oil		Producing Formation									Deepest Zone Tested to End of 1942	
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Range Prod. Sds.		Number of Sands	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells					
						SOUTH LOUISIANA							
71	50	0.1		MioU	S	26	6,400	10,300	5	20	D	Uvigerina	12,214
72	23			Pli	S	Por	1,165	2,400	2	20	Ds	L. Miocene	9,936
	23-40			MioU	S	30	2,800	6,000	7	70	Ds		
	32			MioL	S	25	9,430	9,820	2	35	Ds		
73	32			MioU	S	Por	8,920	9,030	1	80	Ds	U. Miocene	12,005
74	41		Cockfield	Eoc	S	28	7,250	7,452	2	12	AF	Wilcox	11,018
75	37	0.2		MioU	S	32	7,600	10,055	4	20	D	U. Miocene	12,246
76	40			MioU	S	Por	9,350		1	28	D	U. Miocene	10,714
77	33-45			MioU	S	25	8,600	10,900	10	27	D	U. Miocene	11,876
78	49			MioU	S	Por	11,200		1	5	D	U. Miocene	13,409
79	33			Pli	S	Por	2,500		1	50	Ds	U. Miocene	9,887
				MioU	S	Por	7,470		1	30	Ds		
80	32			MioU	S	Por	1,250	6,530	14	28	Ds	L. Miocene	11,049
81	20			MioU	S	27	3,200		1	15	Ds	L. Miocene	9,405
				MioL	S	Por	7,480		1	15	Ds		
82	26			MioU	S	27	2,400	6,300	y	25	Ds	L. Miocene	10,033
	37			MioL	S	38	7,500	8,400	4	25	Ds		
83	36			MioU	S	Por	6,535		1	6	Ds	U. Miocene	6,917
84	35	0.2		MioU	S	Por	5,425	10,385	7	25	Ds	U. Miocene	10,794
85	38	0.13		MioL	S	Por	8,640		1	7	Ds	L. Miocene	10,380
86	30			MioL	S	Por	6,380	7,190	3	15	D	Vicksburg	8,404
87	27			MioU	S	30	8,050	8,150	2	10	D	L. Miocene	11,934
88	35-49			MioU	S	30	4,540	10,730	4	50	D	U. Miocene	12,404
89	29			MioU	S	Por	5,600	9,300	5	40	Ds	U. Miocene	11,012
90	47			MioU	S	Por	9,800		1	55	Ds	U. Miocene	12,012
91	40			MioU	S	Por	6,700	8,300	3	25	D	Marginulina	10,600
	39			MioL	S	Por	9,050		1	15	D		
92	22-30	0.15		MioU	S	35	4,200	5,500	7	30	Ds	L. Miocene	8,480
	37-45			MioL	S	35	7,500	7,900	2	50	Ds		
93	38-48			MioL	S, LS	Por	7,900	8,825	7	27	D	Vicksburg	10,434
94	51			MioL	S	Por	10,437	10,447	1	10	D	L. Miocene	10,447
95				MioU	S	Por	996	1,002	1	10	Ds	U. Miocene	1,496
96	35			MioU	S	Por	3,700	7,800	20	67	Ds	U. Miocene	9,350
97	20			Pli	S	Por	1,300		1	30	Ds	Salt	9,331
	28-42			MioU	S	Por	3,300	5,600	5	30	Ds		
98	34			MioU	S	Por	6,034	9,360	y	30	Ds	U. Miocene	9,569
99	36			MioU	S	Por	7,100	8,900	4	32	D	L. Miocene	11,693
	37			MioL	S	Por	8,400	10,100	3	30	D		
100	22			MioU	S	Por	950	9,250	10	20	D	U. Miocene	10,690
101	44		Cockfield	Eoc	S	Por	5,350	5,500	3	28	Ds	Wilcox	8,230
	44		Sparta	Eoc	S	Por	6,150		1	10	Ds		
102	47			MioL	S	Por	9,300		1	20	D	L. Miocene	9,965
103	34			MioU	S	Por	5,200	6,600	3	25	D	L. Miocene	9,895
104	30	0.12		MioU	S	Por	4,250	7,000	y	45	Ds	L. Miocene	10,013
	29			MioL	S	Por	8,260		6	27	Ds		
105				MioU	S	Por	9,565		1	5	Ds	U. Miocene	11,470
106	45			MioU	S	Por	8,915	8,970	2	18	D	U. Miocene	11,165
107	51			MioU	S	Por	13,000		1	65	D	U. Miocene	13,333
108	42			MioU	S	25	10,750	11,110	2	22	D	U. Miocene	11,494
109	35			MioU	S	Por	8,800	11,300	5	30	D	U. Miocene	12,015
110	33-52			MioU	S	Por	6,700	7,600	2	45	Ds	U. Miocene	9,498
111	27			MioU	S	33	2,700	7,600	8	48	Ds	L. Miocene	11,667
	33			MioL	S	Por	6,150	10,100	5	30	Ds		
112	37			MioU	S	Por	5,900	10,500	7	30	D	U. Miocene	11,163
113	22			MioU	S	Por	3,074	3,187	1	18	Ds	Vicksburg	9,816
114	36	0.04	Cockfield	Eoc	S	Por	6,400		1	20	D	Wilcox	11,935
	48		Sparta	Eoc	S	Por	7,600		1	20	D		
	42		Wilcox	Eoc	S	22	8,500		1	100	D		
115				MioU	S	29	8,700	11,600	7	60	D	L. Miocene	12,005
116	23			Pli	S	20	620	1,100	2	25	Ds	L. Miocene	12,125
	35			MioU	S	Por	6,700	8,700	3	25	Ds		

TABLE I.—(*Continued*)

Line Number	Field, *Parish*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
117	Four Isle Bay, *Terrebonne*	1935	Abandoned		102,512	0
118	Fresh Water Bayou, *Vermilion*	1942		320[2]	0	0
119	Garden Island Bay, *Plaquemines*	1935	360		5,983,911	1,257,904
120	Gibson, *Terrebonne*	1937	480		6,280,822	1,051,716
121	Gillis-English Bayou, *Calcasieu*	1934	1,200		22,051,953	850,347
122	Golden Meadow, *Lafourche*	1938	1,400		14,118,327	4,445,425
123	Grand Bay, *Plaquemines*	1938	1,100		5,797,297	1,996,337
124	Grand Lake, *Cameron*	1939	600		4,376,245	1,167,956
125	Gueydan, *Vermilion*	1932	200		2,632,561	883,464
126	Hayes, *Calcasieu*	1942		320[2]	8,108	8,108
127	Happytown, *St. Martin*	1939	80		428,445	131,824
128	Horseshoe Bayou, *St. Mary*	1937	960		1,765,276	304,352
129	Iberia, *Iberia*	1917	300		26,975,960	2,296,051
130	Iowa, *Calcasieu and Jefferson Davis*	1931	1,040		48,745,540	2,507,194
131	Jeanerette, *St. Mary*	1935	300		10,340,824	668,528
132	Jefferson Island, *Iberia*	1938	160		1,136,376	269,145
133	Jennings, *Acadia*	1901	800	20	80,671,005	4,407,611
134	Kenilworth, *St. Bernard*	1939	40	320	119,499	10,879
135	Krotz Springs, *St. Landry*	1942		320[2]	220	220[3]
136	Lafitte, *Jefferson*	1935	2,600		31,006,502	3,747,260
137	Lafourche Crossing, *Lafourche*	1939	160	80	998,491	30,877
138	Lake Arthur, *Jefferson Davis*	1937		1,600	1,104,084	168,201
139	Lake Barre, *Terrebonne*	1929	500		17,682,001	184,072
140	Lake Chicot, *St. Martin*	1941	240		261,661	233,555
141	Lake Decade, *Terrebonne*	1942	40		14,590	14,590
142	Lake Hermitage, *Plaquemines*	1934	100		155,074	2,649
143	Lake Long, *Lafourche*	1937	640	720	2,426,799	618,323
144	Lake Mongoulois, *St. Martin*	1939		40	101,072	39,254[3]
145	Lake Pelto, *Terrebonne*	1929	110		2,483,697	235,040
146	Lake Salvador, *St. Charles*	1940	680		1,377,448	720,075
147	Lakeside (Lowry), *Cameron*	1941		320	29,911	13,635[3]
148	Lake Washington, *Plaquemines*	1931	200		3,204,206	138,997
149	Lapeyrouse, *Terrebonne*	1941	160		1,104	0
150	LaPice, *St. James*	1939	60	320	314,896	118,248
151	LaPlace, *St. John the Baptist*	1938		320	145,812	71,013[3]
152	Leeville, *Lafourche*	1931	780		24,142,666	1,013,365
153	Lewisburg, *Acadia and St. Landry*	1941		960	29,729	28,319[3]
154	Lirette, *Terrebonne*	1937		1,240	244,822	147,284[3]
155	Little Cheniere, *Cameron*	1940		80	10,079	0
156	Lockport, *Calcasieu*	1924	640		15,019,677	261,305
157	Neale, *Beauregard*	1940	1,340		2,060,510	890,980
158	Nibletts, *Jefferson Davis*	1940	Abandoned		5,390	0
159	North Crowley, *Acadia*	1937	550		6,625,814	1,797,763
160	Northeast Gibson, *Terrebonne*	1941	160		300,142	275,155
161	North Elton, *Allen*	1939		240	35,398	18,682[3]
162	North Tepetate, *Acadia*	1938		1,600	133,054	8,199[3]
163	Paradis, *St. Charles*	1939	5,760		3,702,565	2,248,731
164	Pecan Lake, *Cameron*	1941		640	7,716	3,317[3]
165	Perkins, *Cameron*	1939	Abandoned		0	0
166	Pine Prairie, *Evangeline*	1912	420		1,128,735	875,050
167	Plumb Bob, *St. Martin*	1939	160		348,479	65,281
168	Point au Fer, *Terrebonne*	1941		640	336	225[3]
169	Port Allen, *W. Baton Rouge*	1941	240		263,819	183,928

TABLE I.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Repressuring Operation[d]
				During 1942		End of 1942			Number of Wells		
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	
117	0	0	y	0	0	0	0	0	0	0	
118	0	0	1	1	0	1	0	0	0	0	
119	1,486	621	43	3	0	0	35	0	32	3	
120	6,026	1,967	25	2	0	0	19	2	21	0	
121	31,473	2,159	120	0	13	24	39	2	11	30	
122	6,357	3,378	216	3	7	41	168	0	114	54	
123	4,954	2,158	39	7	0	2	37	0	37	0	
124	3,336	1,071	24	0	y	1	22	0	22	0	
125	2,122	1,300	28	7	y	3	20	0	18	2	
126	491	491	1	1	0	0	0	1	1	0	
127	546	298	2	0	0	0	2	0	2	0	
128	1,622	1,146	10	3	0	2	7	1	8	0	
129	4,458	761	122	0	1	13	80	0	57	23	
130	33,466	3,584	99	2	3	7	64	1	51	14	
131	2,679	834	28	0	1	5	18	0	12	6	
132	1,175	281	12	1	1	0	10	0	7	3	
133	19,560	3,724	704	2	6	41	114	1	53	62	
134	526	209	2	0	0	1	1	0	1	0	
135	0	0	1	1	0	1	0	0	0	0	
136	31,518	3,848	64	5	1	1	61	0	61	0	
137	1,777	424	7	1	0	6	0	1	1	0	
138	18,866	4,580	12	1	y	1	1	9	10	0	
139	781	78	40	0	0	1	21	0	4	17	
140	317	278	7	5	0	0	7	0	7	0	
141	5	5	1	1	0	0	1	0	1	0	
142	81	20	4	0	1	0	0	0	0	3	
143	26,994	11,426	17	1	0	0	10	7	17	0	
144	4,083	1,746	3	0	0	0	0	2	2	0	
145	806	327	21	2	1	1	14	0	11	3	
146	1,107	866	17	7	0	0	17	0	17	0	
147	1,677	732	4	1	0	4	0	0	0	0	
148	y	y	7	0	0	0	7	0	7	0	
149	17	0	1	0	0	1	0	0	0	0	
150	7,077	2,209	4	0	0	0	2	2	4	0	
151	7,732	3,969	3	0	0	0	0	3	3	0	
152	4,120	1,778	132	3	y	28	66	0	16	50	
153	y	573	3	2	0	0	0	3	3	0	
154	28,497	14,494	8	1	0	3	0	5	5	0	
155	211	0	2	0	1	1	0	0	0	0	
156	2,817	154	78	1	1	3	21	0	11	10	
157	1,428	1,021	24	8	0	3	21	0	19	2	
158	4	0	1	0	0	0	0	0	0	0	
159	12,753	4,350	44	0	y	4	39	0	30	9	
160	214	214	6	3	0	0	6	0	6	0	
161	1,792	820	3	0	0	2	0	1	1	0	
162	4,517	241	8	0	0	7	0	1	1	0	
163	3,235	1,827	51	30	0	5	45	1	46	0	
164	347	199	2	0	1	1	0	0	0	0	
165	146	0	1	0	0	0	0	0	0	0	
166	735	682	34	20	1	1	28	0	28	0	
167	71	57	4	0	y	0	3	0	2	1	
168	y	99	2	1	0	2	0	0	0	0	
169	582	403	6	2	1	1	4	0	4	0	

TABLE I.—(*Continued*)

Line Number	Character of Oil		Producing Formation									Deepest Zone Tested to End of 1942	
							Range Prod. Sds.						
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Number of Sands	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
117	44			MioU	S	Por	5,500		1	35	Ds	U. Miocene	10,725
118				MioU	S	Por	11,120		1	15	D	U. Miocene	11,895
119	35			MioU	S	28	4,100	6,900	11	35	Ds	U. Miocene	7,713
120	37			MioU	S	32	8,600	9,450	5	10	D	U. Miocene	11,440
121	31			MioU	S	Por	5,220	5,400	3	30	D	Vicksburg	9,240
	36			MioL	S	Por	6,400	7,050	9	10	D		
122	36			MioU	S	33	2,600	10,700	19	20	D	U. Miocene	12,526
123	36			MioU	S	Por	6,149	9,980	6	15	D	U. Miocene	12,034
124	32			MioU	S	Por	8,200	8,900	5	25	D	L. Miocene	11,386
125	30			MioU	S	Por	4,000	8,750	4	35	Ds	L. Miocene	10,332
	32–51			MioL	S	Por	9,200	10,300	5	50	Ds		
126	44			MioL	S	Por	11,620		1	50	D	L. Miocene	11,785
127	41	0.12		MioL	S	30	9,750	9,950	2	35	D	L. Miocene	10,900
128	38–46			MioU	S	Por	10,180	11,800	4	45	D	U. Miocene	12,777
129	18			Pli	S	Por	800	900	1	50	Ds	U. Miocene	9,968
	24			MioU	S	33	2,800	8,900	14	85	Ds		
130	30			MioU	S	Por	3,800	6,200	5	78	D	Vicksburg	9,287
	36–58			MioL	S	30	7,050	8,100	5	70	D		
131	35			MioU	S	28	6,400	10,250	6	34	D	U. Miocene	11,634
132	33			MioU	S	30	3,070	8,740	6	35	Ds	U. Miocene	9,921
133	25			MioU	S	Por	1,000	1,800	2	16	Ds	Vicksburg	10,766
	38			MioL	S	28	5,400	8,440	6	85	Ds		
134	34			MioU	S	Por	10,350	10,600	2	20	D	L. Miocene	11,469
135	50			MioL	S	Por	9,260		1	70	D		11,403
136	37			MioU	S	29	4,400	10,000	7	45	D	U. Miocene	12,115
137	40			MioU	S	31	9,345	10,132	3	5	D	U. Miocene	11,000
138	53			MioU	S	30	8,500		1	50	D	L. Miocene	12,088
	54			MioL	S	28	9,500	10,100	2	18	D		
139	30			MioU	S	Por	3,645			50	Ds	Salt	11,333
140	40–60			MioU	S	Por	7,220	10,350	4	25	D	L. Miocene	11,800
141	35			MioU	S	Por	10,215		1	5	D	U. Miocene	13,417
142	31	0.06		MioU	S	Por	3,190	9,000	3	23	Ds		
143	45			MioU	S	Por	9,070	10,416	5	36	D	U. Miocene	11,347
144	48			MioL	S	33	9,775		1	60	Ds	L. Miocene	10,778
145	43			Pli	S	Por	1,350		1	25	Ds	U. Miocene	11,478
	34			MioU	S	Por	5,200	11,420	8	47	Ds		
146	34			MioU	S	Por	9,600	10,300	4	34	D	U. Miocene	11,063
147	50			MioU	S	Por	9,820		1	70	D	L. Miocene	11,059
148	18	0.73		Caprock	L	Cav	1,150				Ds	U. Miocene	6,445
149	37			MioU	S	Por	10,900		1	6	D	U. Miocene	10,942
150	39			MioU	S	31	7,800		1	50	D	L. Miocene	11,851
	53			MioL	S	Por	11,000		1	50	D		
151	54			MioU	S	32	8,100	8,900	3	40	D	L. Miocene	11,005
152	32			MioU	S	Por	3,000	9,000	29	33	Ds	U. Miocene	10,328
153	53			MioL	S	30	9,090	10,175	2	20	D	L. Miocene	10,782
154	51	0.34		MioU	S	Por	8,450	10,520	2	50	D	U. Miocene	12,165
155	47			MioU	S	28	10,185		1	10	D	U. Miocene	10,655
156	23			Pli	S	Por	1,000	4,300	3		Ds	Salt	8,187
	32			MioU	S	Por	5,300	5,500	2		Ds		
	41			MioL	S	Por	6,400	6,600	2	20	Ds		
157	37–46		Wilcox	Eoc	S	22	8,300	11,075	3	20	D	Cretaceous ?	12,584
158	42	0.2		MioL	S	Por	11,600		1	16	D	L. Miocene	11,748
159	38	0.7		MioU	S	Por	7,180		1	26	D	L. Miocene	10,652
	36			MioL	S	Por	7,744	8,760	5	20	D		
160	37			MioU	S	Por	9,000	9,500	2	10	D	U. Miocene	10,535
161	53			MioL	S	Por	7,400		1	15	D	Vicksburg	9,010
162	44–55			MioL	S	30	7,900	9,000	4	22	D	Marginulina	9,487
163	37			MioU	S	25	9,550	11,150	5	60	D	U. Miocene	11,555
164	46			MioU	S	Por	10,140		1	45	D	L. Miocene	10,140
165				MioL	S	Por	7,038		1	25	D	Cockfield	9,450
166	40		Cockfield	Eoc	S	27	7,530	8,350	1	40	Ds	Wilcox	9,554
	40–47		Sparta	Eoc	S	Por	8,906	9,470	1	30	Ds		
167	34			MioL	S	24	8,300	9,100	2	30	Ds	L. Miocene	9,771
168	57			MioU	S	Por	5,608	6,750	2	15	D	U. Miocene	11,732
169	36			MioL	S	30	9,100	9,600	3	20	D	L. Miocene	10,044

TABLE 1.—(*Continued*)

Line Number	Field, *Parish*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
170	Port Barre, *St. Landry*	1929	500		10,800,490	951,374
171	Potash, *Plaquemines*	1937	160		1,646,511	607,162
172	Quarantine Bay, *Plaquemines*	1937	17,000		7,149,793	2,098,159
173	Rabbit Island, *Iberia*	1942		320[2]	0	0
174	Raceland, *Lafourche*	1938	400	400	2,374,358	599,879
175	Richie, *Acadia*	1941	320		408,369	260,810
176	Roanoke, *Jefferson Davis*	1934	960		9,753,544	611,292
177	St. Gabriel, *Iberville*	1941	1,250		1,883,390	1,346,714
178	St. Martinville, *St. Martin*	1935	80		1,294,748	59,891
179	Section 28, *St. Martin*	1940	120		35,533	16,335
180	Sorrento, *Ascension*	1928	100		1,191,244	45,487
181	South Crowley, *Acadia*	1938	200		116,995	24,375
182	South Elton, *Jefferson Davis*	1937		640	65,069	5,879[3]
183	South Houma, *Terrebonne*	1938	80		573,870	97,906
184	South Jennings, *Jefferson Davis*	1936		1,500	141,300	9,662[3]
185	South Thornwell, *Jefferson Davis*	1942		320[3]	538	538[3]
186	Starks, *Calcasieu*	1925	150		3,479,025	176,190
187	Stella, *Plaquemines*	1940	500		407,095	203,849
188	Sulphur Mines, *Calcasieu*	1926	200		16,719,878	776,271
189	Sweet Lake, *Cameron*	1926	200		6,132,128	612,051
190	Tepetate, *Acadia*	1935	1,000		11,429,730	993,251
191	Timbalier Bay, *Lafourche*	1938	80		241,473	31,899
192	University, *E. Baton Rouge*	1938	900		11,992,234	3,285,848
193	Unknown Pass, *Orleans*	1941	80		8,955	5,656[3]
194	Vacherie (Hester), *St. James*	1938	40		103,332	18,412
195	Valentine, *Lafourche*	1936	240		5,413,682	241,306
196	Venice, *Plaquemines*	1937	400		4,504,407	1,302,618
197	Vermilion Bay, *Iberia*	1939	40		391,694	134,899
198	Ville Platte, *Evangeline*	1937	5,200		21,230,247	6,439,740
199	Vinton, *Calcasieu*	1910	360		43,520,841	367,688
200	Welsh, *Jefferson Davis*	1902	150		692,327	16,094
201	West Bay, *Plaquemines*	1940	560	80	1,167,394	742,596
202	West Cote Blanche Bay, *St. Mary*	1940	600		922,951	477,774
203	West Gueydan, *Vermilion*	1938	240		697,428	168,405
204	West Hackberry, *Cameron*	1927	600	20	9,768,987	1,827,864
205	West Lake Verret, *St. Martin*	1938	800		1,832,192	876,766
206	West Mermentau, *Jefferson Davis*	1940	40	320	33,438	19,454
207	Westwego, *Jefferson*	1941	120		139,214	104,724
208	White Castle, *Iberville*	1929	540		6,095,591	913,259
209	Woodlawn, *Jefferson Davis*	1938	400	700	3,575,745	829,199

(TABLE 1.—*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Repressuring Operation[d]
				During 1942		End of 1942			Number of Wells		
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	
170	948	376	81	7	4	5	46	1	21	25	
171	746	342	17	2	0	1	13	1	14	0	
172	5,975	2,544	43	5	1	0	40	0	40	0	
173	0	0	1	1	0	1	0	0	0	0	
174	6,658	2,440	15	5	0	1	12	1	13	0	
175	8	8	12	2	y	0	11	0	7	4	
176	21,224	2,065	32	1	6	2	17	1	9	9	
177	642	642	25	4	0	0	25	0	25	0	
178	407	19	2	0	0	0	2	0	2	0	
179	191	4	2	0	0	1	1	0	1	0	
180	40	2	12	1	0	2	6	0	4	2	
181	104	34	6	0	4	1	1	0	1	0	
182	1,795	163	1	0	0	1	0	0	0	0	
183	2,402	521	2	0	0	0	2	0	2	0	
184	18,445	11,433	8	0	0	2[19]	0	5	5	0	
185	35	35	1	1	0	1	0	0	0	0	
186	30	28	41	6	y	3	26	0	3	23	
187	520	197	8	2	0	0	7	0	7	0	
188	1,326	201	132	2	14	19	66	0	7	59	
189	y	88	23	1	1	2	17	0	17	0	
190	58,338	8,988	63	0	2	5[20]	44	0	37	7	PM
191	24	9	2	0	0	0	2	0	1	1	
192	16,848	6,571	99	4	0	8	73	9	58	24	
193	50	49	2	0	0	0	2	0	2	0	
194	644	25	2	0	0	0	0	0	1	0	
195	2,070	153	35	0	9	8	16	0	3	13	
196	3,845	1,191	30	7	0	0	24	0	24	0	
197	506	220	3	1	0	0	3	0	3	0	
198	123,862	49,790	227[18]	24	1	61[21]	185	0	158	27	PM
199	26	24	451	3	1	36	58	0	3	55	
200	264	180	y	0	3	8	13	0	0	13	
201	1,333	974	17	3	0	2	15	0	15	0	
202	696	570	15	7	y	0	14	0	10	4	
203	438	314	8	2	y	0	7	0	3	4	
204	4,178	16	85	2	y	4	68	1	33	36	
205	4,638	2,496	28	5	0	1	25	1	17	9	
206	1,232	682	2	1	0	0	1	1	2	0	
207	862	601	4	1	0	0	4	0	4	0	
208	2,714	455	27	2	y	1	20	0	11	9	
209	20,758	6,286	32	0	y	7	16	6	21	1	

[18] Dual completions.
[19] Input wells.
[20] Includes two input wells.
[21] Includes 15 input wells.

TABLE 1.—(*Continued*)

Line Number	Character of Oil		Producing Formation									Deepest Zone Tested to End of 1942	
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Range Prod. Sds.		Number of Sands	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells					
170				MioU	S	Por	1,300		1		Ds	L. Miocene	8,376
	21-60			MioL	S	32	3,100	7,500	14	43	Ds		
	26			Olig	S	Por	3,600		1	20	Ds		
	36		Claiborne	Eoc	S	Por	5,116		1	10	Ds		
171	28	0.1		MioU	S	Por	4,160	8,680	9	40	Ds	U. Miocene	10,027
172	53			MioU	S	Por	7,690	9,525	10	16	D	U. Miocene	10,536
173				MioU	S	Por	8,670		1	30	D	U. Miocene	9,338
174	36			MioU	S	Por	7,200	12,100	3	30	D	U. Miocene	12,196
175	25			MioU	S	Por	3,500		1	15	D	U. Miocene	4,271
176	33-57			MioL	S	26	6,260	8,850	6	56	D	Vicksburg	10,750
177	33			MioL	S	28	7,770	8,600	2	110	D	L. Miocene	10,542
178	31			MioU	S	Por	5,500		1	50	D	L. Miocene	9,645
179	27-47			MioL	S	Por	8,906	10,200	2	25	Ds	L. Miocene	11,303
180	23	0.5		Pli	S	Por	900	1,300	2	40	Ds	L. Miocene	8,004
	24			MioL	S	Por	4,300		2	20	Ds		
181	29-53	0.10		MioU	S	25	4,364	7,602	5	15	D	Marginulina	10,272
				MioL	S	Por	8,900		1	17	D		
182	50			MioL	S	30	8,950		1	30	D	Claiborne	13,210
183	37	0.1		MioU	S	Por	10,150	10,300	2	30	D	U. Miocene	11,344
184	50			MioU	S	31	8,600		1	45	D	Marginulina	10,953
	50			MioL	S	31	8,800	9,500	2	15	D		
185	53			MioL	S	Por	9,625	9,645	1	17	D	L. Miocene	10,325
186	18			Pli	S	Por	570		1	20	Ds	L. Miocene	11,344
	18			MioU	S	Por	740	3,820	4	15	Ds		
	20-40			MioL	S	Por	3,986	6,018	7	15	Ds		
187	40	0.12		MioU	S	32	7,000	10,000	4	15	D	U. Miocene	10,807
188	27			MioU	S	Por	2,760		1	20	Ds	L. Miocene	7,563
	17-40			MioL	S	Por	4,100	6,800	6	30	Ds		
189	30			MioU	S	Por	5,600	7,300	9	30	D	L. Miocene	9,179
190	41			MioL	S	25	8,300	9,165	2	60	D	L. Miocene	9,447
191	27			MioU	S	Por	5,330	6,760	2	15	Ds	Salt	8,727
192	36			MioU	S	35	4,200	7,200	5	30	D	L. Miocene	10,362
	43			MioL	S	Por	9,300	9,500	3	10	D		
193	52			MioL	S	Por	9,890		1	10	D	L. Miocene	10,405
194	36	0.1		MioU	S	Por	6,345		1	50	Ds	L. Miocene	10,012
195	33			MioU	S	Por	3,800	6,900	7	50	Ds	L. Miocene	10,012
196	41			MioU	S	30	3,600	10,800	10	65	Ds	U. Miocene	11,402
197	33			MioU	S	29	10,120	10,760	2	30	Ds	U. Miocene	11,603
198	40-60		Sparta	Eoc	S	21	8,700	9,100	2	30	D	Wilcox	12,527
	36-46		Wilcox	Eoc	S	21	9,600	10,250	4	35	D		
199	22			MioU	S	Por	1,850	4,920	9	15	Ds	Salt	6,939
200	22			Pli	S	Por	1,200		1	15	Ds	Hackberry	10,358
	37-47			MioL	S	Por	6,120	7,400	3	5-80	Ds		
201	34			MioU	S	Por	6,260	7,270	4	20	Ds	Salt	10,015
202	21-34			MioU	S	Por	2,000	9,200	9	30	Ds	U. Miocene	9,707
203	39-62			MioU	S	Por	6,600	10,900	4	12	D	L. Miocene	11,000
204	21			MioU	S	25	3,050		1	39	Ds	L. Miocene	10,010
	31			MioL	S	30	4,150	9,900	8	50	Ds		
205	24-37	0.10		MioU	S	28	1,300	8,750	10	47	D	L. Miocene	11,678
	35			MioL	S	28	8,850	11,500	2	45	D		
206	47-57			MioL	S	Por	9,100	10,200	2	10	D	L. Miocene	10,581
207	36			MioU	S	30	9,000		1	4	D	U. Miocene	11,151
208	28			MioU	S	32	5,150	8,750	5	196	Ds	L. Miocene	9,400
209	34-51			MioL	S	30	7,480	9,300	10	25	D	L. Miocene	10,194

TABLE 2.—*Wildcat Wells Completed in Louisiana during 1942*

	Parish and Operator	Lease and Well No.	Location			Date Abandoned	Total Depth, Ft.	Abandoned in	Remarks
			Sec.	Tp.	Rge.				
			NORTH LOUISIANA						
	Avoyelles Parish								
1	H. L. Hunt.....	J. H. Hines Timber Co. No. 1	11	4 N	4 E	9/ ?/42	7,311	Wilcox	Saline Lake area
2	Placid Oil Co....	Southwestern Imp. Co. No. A-1	19	2 N	7 E	1/21/42	7,800	Wilcox	
3	Placid Oil Co....	Southwestern Imp. Co. No. D-1	11	2 N	7 E	1/20/42	7,474	Wilcox	
4	Placid Oil Co....	Thompson & Katz No. 1	4	2 N	5 E	3/18/42	7,800	Wilcox	Lake Latagnier prospect
5	Placid Oil Co....	Thompson & Katz No. 2	35	3 N	5 E	9/ 2/42	7,228	Wilcox	Lake Latagnier prospect
	Bienville Parish								
6	Arkansas Fuel Oil Co...........	E. W. Merritt No. 1	13	17 N	7 W	7/ 2/42	7,760	Hosston	
7	C. M. Bagley....	Mrs. J. W. Hutton No. 1	4	18 N	7 W	6/28/42	2,795	U. Cretaceous	3 miles NW. of Gibsland salt dome
8	R. E. Collins....	J. R. Madden Heirs No. 1	3	16 N	8 W	1/ ?/42	2,020	U. Cretaceous	4 miles S. of Vacherle salt dome
	Bossier Parish								
9	W. G. Coates....	Bellevue Land Co. No. 1	27	20 N	11 W	2/ ?/42	2,930	L. Cretaceous	5 miles N. of Bellevue field
10	Continental Oil Co.	Crystal Oil Ref. Co. No. 1	21	21 N	11 W	8/ ?/42	5,660	Rodessa	4 miles W. of Cotton Valley field
11	G. W. Dawley...	Sentell & Dickson No. 1	10	20 N	13 W	10/ 9/42	95		Temporarily abandoned
12	Oscar Donley....	Carrie Howell No. 1	4	18 N	11 W	4/ ?/42	1,027	U. Cretaceous	4 miles SW. of Bellevue field
13	Hunt Oil Co.....	F. Bilbray No. 1	5	23 N	11 W	10/21/42	6,485	Hosston	4 miles NE. of Carterville field
14 15	J. C. Robbins and H. G. Lewis...	Ellerbe No. 1	3	20 N	13 W	10/ 2/42	2,270	U. Cretaceous	Temporarily abandoned
	Caddo Parish								
16	Cioban Oil Co...	Horne No. 1	16	16 N	15 W	6/ ?/42	150		Temporarily abandoned
17	H. C. Owens....	J. D. Wilkinson No. 1	34	23 N	15 W	10/ 5/42	6,016	Rodessa	3 miles SE. of Rodessa field
18	G. K. Primos....	Casper Gerdes, Jr. No. 1	4	14 N	16 W	8/11/42	1,602	U. Cretaceous	
19	Steve Reele.....	Fly No. 1	21	19 N	16 W	8/21/42	3,041	L. Cretaceous	Temporarily abandoned
20	D. D. Richardson	Tri State Realty Co. No. 1	27	19 N	14 W	8/21/42	3,000	L. Cretaceous	Temporarily abandoned
21	Transport Oil Co.	Wilkinson No. 1	22	20 N	14 W	2/25/42	947	U. Cretaceous	
22	Transport Oil Co.	Wilkinson No. 2	22	20 N	14 W	5/28/42	976	U. Cretaceous	
23	Transport Oil Co.	Wilkinson No. 3	22	20 N	14 W	5/28/42			
	Caldwell Parish								
24	J. W. Love Co...	La. Central Lbr. Co. No. 1	29	13 N	4 E	11/ 8/42	4,570	U. Cretaceous	
25	Mudge Oil Co...	International Paper Co. No. 2	6	11 N	4 E	4/27/42	3,521	Wilcox	
26	J. T. Parks......	La Central Lbr. Co. No. 1	6	11 N	3 E	3/24/42	3,906	Midway	3 miles N. of Standard field
27	Southern Carbon Co.	Vollie Howard No. 1	13	14 N	4 E	2/ 5/42	4,000	U. Cretaceous	Tested several shows in Upper Cretaceous and Wilcox
28	W. B. White....	Arch McDaniels No. 1	10	11 N	3 E	9/25/42	4,080	Midway	2½ miles NE. of Standard field
	Catahoula Parish								
29	J. F. Belt Co....	Baker Est. No. 1	1	6 N	6 E	8/24/42	5,825	Wilcox	½ mile N. of Willow Lake field
30	Carter Oil Co....	W. R. Davis No. 1	29	5 N	6 E	2/23/42	7,386	Midway	
31	Carter Oil Co....	Zenoria Lbr. Co. No. 2	11	8 N	6 E	6/11/42	5,195	Wilcox	
32	Continental Oil Co...........	J. M. Jones No. 1	35	10 N	8 E	10/19/42	6,003	Wilcox	
33	H. A. Harper, et al	Graham, Stave and Heading No. 1	8	8 N	7 E	5/22/42	6,001	Midway	
34	Hunt Oil Co.....	La. Central Lbr. Co. No. 1	19	9 N	6 E	12/21/42	5,632	Midway	3 miles E. of Manifest field
35	H. L. Hunt......	La. Delta Hdw.—Tensas Delta No. A-2	8	4 N	5 E	11/ ?/42	7,182	Wilcox	Saline Lake area
36	H. L. Hunt......	La. Delta Hdw.—Tensas Delta No. C-1	33	5 N	5 E	4/12/42	6,640	Wilcox	4 miles SW. of Larto Lake field
37	Placid Oil Co....	J. E. Burroughs No. 1	34	7 N	6 E	9/20/42	6,697	Wilcox	
38	Placid Oil Co....	Grant Tbr. & Mfg. Co. No. 2	29	6 N	6 E	1/ 3/42	6,571	Wilcox	4 miles SW. of Willow Lake field

TABLE 2.—(*Continued*)

	Parish and Operator	Lease and Well No.	Location			Date Abandoned	Total Depth, Ft.	Abandoned in	Remarks
			Sec.	Tp.	Rge.				
	Catahoula Parish (cont.)								
39	Julian E. Simon Co.	Knotts No. 1	29	11 N	8 E	11/12/42	5,325	Wilcox	
40	Sinclair Prairie Oil Co.	Tensas Delta Land Co. No. 1	6	7 N	5 E	2/10/42	6,018	Midway	
41	Sinclair Prairie Oil Co.	Tensas Delta Land Co. (Block 3) No. 1	10	8 N	5 E	3/13/42	6,028	Midway	
42	N. H. Wheless	La. Delta Hdw. Lbr. Co. No. C-1	1	6 N	5 E	10/15/42	6,314	Wilcox	
43	N. H. Wheless	La. Delta Hdw. Lbr. Co. No. D-1	5	3 N	5 E	2/ 7 42	8,060	Wilcox	
	Claiborne Parish								
44	Houston & Weiner	R. B. Wilson No. 1	6	23 N	5 W	11/ ?/42	5,200	Hosston	
45	Hunt Oil Co.	M. B. Mitchiner No. 1	15	23 N	7 W	2/24/42	11,255	Eagle Mills salt	Deep test on Lower Cretaceous high of Haynesville structure, about 3 miles E. of producing area
46	Hunt Oil Co.	W. T. & S. W. Owens No. 1	13	23 N	7 W	6/10/42	6,012	Hosston	Deep test on Lower Cretaceous high of Haynesville structure, about 6 miles E. of producing area
47	Skelly Oil Co.	M. M. Kinnebrew No. 1	26	20 N	7 W	8/20/42	6,843	Hosston	1½ miles NW. of production at Athens
48	C. C. Smyer	H. A. Kennedy Est. No. 1	9	22 N	4 W	3/ ?/42	3,010	U. Cretaceous	Temporarily abandoned
49	F. R. Sylvestre	W. T. McElwee No. 1	11	22 N	7 W	10/18/42	6,005	Hosston	5 miles SE. of Haynesville field
	Concordia Parish								
50	The California Company	State—Lake Concordia No. 1	in lake	8 N	9 E	5/19/42	6,725	Wilcox	
51	Wm. Herbert Hunt, Tr.	A. B. Learned No. 1	18	8 N	10 E	6/ 9/42	6,930	Midway	
52	Est. & Lamar Hunt, Tr. Est.								
53	The Texas Company	Madison Oil & Dev. Co. No. 1	30	5 N	8 E	9/29/42	6,962	Wilcox	Deer Park area
	De Soto Parish								
54	A. E. Roscoe & A. G. Carter	McGill No. 1	1	10 N	13 W	1/17/42	2,006	U. Cretaceous	2 miles E. of depleted Benson field
	East Carroll Parish								
55	Roeser & Pendleton, Inc.	J. L. Logan No. 1	14	23 N	13 E	11/ 7/42	6,007	Jurassic	
	Grant								
56	Algord Oil Co. & Johnson & Burnham	J. W. Dubois No. 1	9	7 N	4 W	2/19/42	4,863	Wilcox	
57	Carter Oil Co.	H. McGinty No. 1	20	7 N	1 E	5/24/42	4,712	Wilcox	
58	J. E. Grandstaff	Matherson Est. No. 1	15	9 N	1 E	9/10/42	3,085	Wilcox	½ mile S. of producing area at Georgetown
	La Salle Parish								
59	Atlantic Ref. Co.	State—Catahoula Lake No. 1	27	7 N	4 E	4/12/42	5,499	Midway	3 miles NE. of Catahoula Lake field
60	Carter Oil Co.	State—Catahoula Lake No. C-1	36	7 N	3 E	5/ 7/42	5,274	Midway	1½ miles NW. of Catahoula Lake field and 1½ miles SE. of Nebo-Hemphill field
61	Carter Oil Co.	State-Catahoula Lake No. D-2	27	6 N	3 E	7/14/42	5,731	Midway	2 miles W. of Indian Bayou field
62	H. L. Hunt	Goodpine Oil Co. No. F-117	7	7 N	4 E	8/24/42	5,245	Midway	2½ miles E. of Nebo-Hemphill field
63	H. L. Hunt	La. Delta Hdw—Tensas Delta No. B-1	35	5 N	4 E	3/ 5/42	7,142	Midway	Saline Lake area
64	H. L. Hunt	La. Delta Hdw.—Tensas Delta No. E-1	2	4 N	4 E	11/19/42	6,180	Wilcox	Saline Lake area
65	T. L. James	State—Catahoula Lake No. 1	29	7 N	4 E	11/ 2/42	4,200	Wilcox	2 miles NE. of Catahoula Lake field
66	Peterson Pet. Corp.	Drewett Unit No. A-1	6	8 N	4 E	8/23/42	5,023	Midway	
67	Phillips Petroleum Co.	Tensas Delta Land Co. No. C-1	28	6 N	4 E	10/ 9/42	5,871	Midway	

TABLE 2.—(*Continued*)

	Parish and Operator	Lease and Well No.	Location			Date Abandoned	Total Depth, Ft.	Abandoned in	Remarks
			Sec.	Tp.	Rge.				
	La Salle Parish (cont.)								
68	Phillips Petroleum Co.	Tensas Delta Land Co. No. H-1	15	5 N	4 E	2/27/42	6,570	Midway	
69	Aubrey M. Poynter.......	Heard Est. No. 1	13	8 N	3 E	9/15/42	3,654	Wilcox	
70	N. H. Wheless...	La. Delta Hdw. Lbr. Co. No. E-1	10	6 N	4 E	7/25/42	5,689	Midway	
	Lincoln Parish								
71	Carter Oil Co....	T. J. Green No. 1	2	17 N	3 W	3/19/42	6,875	L. Cretaceous	
	Madison Parish								
72	Continental Oil Co..........	R. B. Watts No. 1	40	15 N	13 E	6/ 2/42	3,387	Wilcox	
73	Continental Oil Co..........	R. B. Watts No. 2	41	15 N	13 E	7/14/42	5,447	Midway	
74	Continental Oil Co.	G. W. Patterson No. 1	7	16 N	12 E	9/ 5/42	3,046	Salt	New salt dome: Tallulah, top of salt 3025 feet
75	C. H. Murphy...	J. K. Mahony No. 1	34	17 N	13 E	12/22/42	6,005	L. Cretaceous	
	Natchitoches Parish								
76	George Echols...	Goodpine Oil Co. No. 1	13	13 N	8 W	12/ ?/42	8,932	Cotton Valley	
77	George Echols-McDermott	Union Sawmill Co. No. 1	24	6 N	7 W	2/26/42	5,812	Wilcox	
78	H. L. Hunt......	Goodpine Oil Co. No. F-23	12	13 N	7 W	3/17/42	4,735	L. Cretaceous	
79	C. Porter Johnson	Sam Lecaze No. 1	63	6 N	4 W	1/28/42	4,639	Wilcox	
	Rapides Parish								
80	R. S. Bond......	J. A. O'Neal Est. No. 1	20	5 N	3 E	4/28/42	6,015	Wilcox	
81	Carter Oil Co....	State-Catahoula Lake No. B-1	32	6 N	3 E	1/26/42	5,755	Wilcox	
	Red River Parish								
82	Cryer & Reese...	J. T. Biles No. 1	25	12 N	9 W	11/ ?/42	2,510	U. Cretaceous	
83	Cryer & Reese...	Stephens & Co. No. 1	27	12 N	9 W	9/14/42	3,409	L. Cretaceous	
84	C. C. Lowery....	Ed. Lester No. 1	41	12 N	10 W	6/19/42	3,515	L. Cretaceous	
	Richland Parish								
85	Calhoun, Jones & Gower	McCoy Inc. No. 1	29	16 N	6 E	8/ 9/42	4,517	Rodessa	Wildcat in depleted Richland field
86	Bobby Manziel..	M. E. Wooten No. 1	28	15 N	5 E	4/16/42	4,005	L. Cretaceous	On SW. flank of Richland structure
	Sabine								
87	O. R. Bollinger..	Long Bell Lbr. Co. No. 1	18	8 N	13 W	4/ ?/42	255		
88	R. L. Gay.......	Long Bell Lbr. Co. No. 1	12	7 N	14 W	3/ ?/42	2,576	U. Cretaceous	
89	J. H. Trotter....	Lake Charles Bank & Trust Co. No. 1	5	5 N	12 W	1/28/42	2,535	U. Cretaceous	
	Tensas Parish								
90	Carter Oil Co....	Desha Lbr. Co. (H. L. Jacoby) No. 1	34	14 N	11 E	7/10/42	4,400	Salt	New salt dome: Somerset, top of salt 4073
91	Carter Oil Co....	Grace M. Rhoades Unit No. 1	29	9 N	10 E	1/15/42	6,599	Midway	2 miles NW. of Lake St. John field
92	Continental Oil Co.	W. W. Burnside No. 1	70	13 N	12 E	8/14/42	4,448	Salt	SE. flank Newellton dome
93	Las Tecas Pet. Co.	Weatherly No. 1	38	12 N	12 E	9/ ?/42	5,190	Wilcox	Twisted off drill stem and moved 50′ N. for Weatherly No. A-1
94	Las Tecas Pet. Co...........	Weatherly No. A-1	38	12 N	12 E	10/17/42	6,113	Midway	
	Union Parish								
95	Carter Oil Co....	W. H. Weldon Unit No. 1	19	21 N	2 W	1/ 9/42	5,644	L. Cretaceous	
96	Ward Delaney..	Taylor No. 1	12	19 N	1 E	5/30/42	5,104	L. Cretaceous	
	Vernon Parish								
97	Shell Oil Co.....	La. Long Leaf Lbr. Co. No. 1	15	4 N	9 W	5/25/42	7,500	Midway	
	Webster Parish								
98	Magnolia Petroleum Co.	W. B. Warren No. 1	12	22 N	9 W	6/ 3/42	6,008	Hosston	4 miles SE. of Shongaloo field
	West Carroll Parish								
99	Continental Oil Co.	Chicago Mill & Lbr. Co. No. 1	23	20 N	9 E	11/10/42	2,879	U. Cretaceous	
100	Continental Oil Co.	Chicago Mill & Lbr. Co. No. 2	20	20 N	9 E	12/ ?/42	2,845	U. Cretaceous	
	Winn Parish								
101	H. L. Hunt......	Goodpine Oil Co. No. F-12	21	10 N	1 W	1/16/42	3,884	Midway	
102	H. L. Hunt......	Goodpine Oil Co. No. F-72	19	10 N	4 W	2/16/42	6,305	L. Cretaceous	Deep test on N. flank of Coochie Brake salt dome
103	Placid Oil Co....	H. E. Davis et al. No. 1	19	13 N	2 W	9/26/42	6,450	Mooringsport	

TABLE 2.—(*Continued*)

	Parish and Operator	Lease and Well No.	Location			Date Abandoned	Total Depth, Ft.	Abandoned in	Remarks
			Sec.	Tp.	Rge.				
				SOUTH LOUISIANA					
	Acadia Parish								
104	Continental Oil Co.	Homeseekers Development Co. No. 1	16	10 S	1 W	4/11/42	12,126	L. Miocene	Gas show at 10,500 to 600 ft.
105	Vincent & Welch	A. Ardoin No. 1	19	7 S	2 W	3/23/42	9,448	L. Miocene	Blew out and lost hole at 9448 ft. Made some 37° oil; one mile W. Tepetate
	Ascension Parish								
106	Humble Oil & Ref. Co.......	L. P. Gautreau No. 1	8	9 S	3 E	8/21/42	10,700	L. Miocene	Duplessis prospect
	Assumption Parish								
107	George Echols...	Armelise Plantation No. 2	139	12 S	14 E	2/ 3/42	9,131	Salt	E. flank Napoleonville dome, salt at 9107 ft.
108	Wm. Helis......	Dugas & Le Blanc No. 1	55	12 S	13 E	7/31/42	11,128	L. Miocene	S. flank Napoleonville dome
	Calcasieu Parish								
109	W. T. Burton...	Industrial Lumber Co. No. 5	29	9 S	12 W	3/ 4/42	7,856	L. Miocene	SE. flank Starks dome, one mile from production
110	W. T. Burton...	Industrial Lumber Co. No. 9	25	9 S	13 W	10/ 5/42	5,878	L. Miocene	SW. flank Starks dome, 3600 ft. from production
111	Gulf Refining Co., G.P.D.	The Hunter Co., Inc. No. 1	22	9 S	11 W	6/26/42	5,308	Salt	NE. flank Edgerly dome, salt at 5303 ft.
112	Gulf Refining Co., G.P.D.	The Hunter Co., Inc. No. 2	22	9 S	11 W	8/28/42	6,384	L. Miocene	NE. flank test. Edgerly
113	Gulf Refining Co., G.P.D.	Louisiana Sulphur Mining Co. No. 1	33	9 S	11 W	6/16/42	9,816	Vicksburg	S. flank Edgerly dome, 4000 ft. from production
114	Union Oil Co. of California.....	Matilda Gray No. 1	4	11 S	9 W	1/27/42	10,401	L. Miocene	Moss Lake area
115	Union Oil Co. of California	M. Gray No. 1-G	32	10 S	12 W	4/20/42	5,248	U. Miocene	W. flank Vinton dome, 3000 ft. from shallow production
116	Union Oil Co. of California	M. Gray No. 2-G	32	10 S	12 W	7/ 5/42	6,307	L. Miocene	W. flank Vinton dome, 4000 ft. from shallow production
	Cameron Parish								
117	Pure Oil Co.....	Miami Corporation No. 1	7	13 S	7 W	5/ 8/42	9,054	U. Miocene	4500 ft. SE. of production at Sweet Lake
118	Pure Oil Co.....	Miami Corporation No. 2	18	13 S	7 W	9/11/42	9,177	U. Miocene	6500 ft. SE. of production at Sweet Lake
119	Superior Oil Co..	Miami Corporation No. D-1	34	13 S	5 W	6/ 1/42	10,453	U. Miocene	Lake Misere area, blew out at 9949 to 9971 ft.
120	Union Sulphur Co.	A. Hebert No. 1	12	12 S	9 W	3/27/42	10,600	L. Miocene	One mile NW. of depleted production at Big Lake
	Evangeline Parish								
121	Continental Oil Co., and Humble Oil & Ref. Co.	The Pardee Co. No. 2	24	4 S	2 W	8/14/42	12,686	Wilcox	Reddell prospect, 400 ft. fault in Cane River Section
	Iberia Parish								
122	Amerada Petroleum Corp....	Williams Inc., et al. No. 1	19	12 S	11 E	5/22/42	11,899	U. Miocene	One mile SE. Bayou Pigeon field
123	Paul G. Benedum	Louisiana Land and Exploration Co. No. 1	4	13 S	7 E	2/22/42	9,017	U. Miocene	
124	Humble Oil and Ref. Co.	Petit Anse Co., Inc. No. 1	25	13 S	5 E	3/19/42	7,000	Salt	SW. flank Avery Island dome, salt overhang at 5934 to 5945 ft.; top main salt stock at 6269 ft., tried to blow out between overhang and main salt stock.
125	Shell Oil Co., Inc.	J. A. Smith No. 1	18	14 S	7 E	2/21/42	11,510	U. Miocene	NE. flank Weeks Island dome
126	Sun Oil Co......	Kling and Walet No. 10	27	11 S	8 E	7/13/42	9,068	L. Miocene	W. flank Fausse Pointe dome, 6000 ft. from production
	Iberville Parish								
127	Amerada Petroleum Corp.	Dewey Angelloz No. 1	41	7 S	10 E	9/22/42	10,426	L. Miocene	Blew out and caught fire—Junked

TABLE 2.—(*Continued*)

	Parish and Operator	Lease and Well No.	Location			Date Abandoned	Total Depth, Ft.	Abandoned in	Remarks
			Sec.	Tp.	Rge.				
	Iberville Parish (cont.)								
128	Humble Oil & Ref. Co.	E. B. Schwing No. B-1	86	8 S	8 E	5/24/42	6,620	Salt	SE. flank Bayou des Glaises dome
129	Phillips Petroleum Co......	E. B. Schwing No. 1	15	10 S	10 E	6/ 8/42	11,066	L. Miocene	
	Jefferson Parish								
130	The Texas Company	Lafourche Basin Levee District No. A-2	29	19 S	24 E	6/20/42	11,436	U. Miocene	One mile NW. production at Bay de Chene
131	The Texas Company	Lafourche Basin Levee District No. A-3	33	19 S	24 E	12/21/42	9,497	U. Miocene	One mile SE. production at Bay de Chene
132	The Texas Company	Leon Rojas, et al. No. 1	23	17 S	24 E	5/31/42	10,742	U. Miocene	One mile E. production at Lafitte
	Jefferson Davis Parish								
133	Union Sulphur Co.	F. C. Perl No. 1	7	9 S	3 W	5/31/42	9,641	L. Miocene	4000 ft. E. production at Roanoke
134	Union Sulphur Co.	T. Levergne No. 1	6	9 S	3 W	3/28/42	9,537	L. Miocene	One mile E. production at Roanoke
	Lafourche Parish								
135	Amerada Petroleum Corp. & Stanolind Oil & Gas Co.......	C. E. Gheens No. 9	37	15 S	20 E	11/28/42	10,702	Miocene	6000 ft. S. production at Bayou des Allemands.
136	Ernest Cockrell, et al.	Lafourche Land Co. No. 2	32	18 S	22 E	1/16/42	7,512	U. Miocene	Bay Brusle area
137	Shell Oil Co., Inc.	Edna Plantation No. 1	65	17 S	20 E	3/12/42	9,815	U. Miocene	One mile SW. production At Valentine
138	Shell Oil Co., Inc.	Edna Plantation No. 2	66	17 S	20 E	6/13/42	9,786	U. Miocene	One-half mile SW. production at Valentine
139	The Texas Company	Laterre Co., Inc., No. 13	11	20 S	21 E	1/26/42	5,575	U. Miocene	One mile S. production at Golden Meadow
	Livingston Parish								
140	Danciger Oil & Ref. Co.	Dendinger, Inc. No. 1	37	8 S	7 E	6/ 7/42	10,447	Vicksburg	Slight shows in L. Miocene
	Orleans Parish								
141	W. T. Burton...	L. & N.R.R. No. A-1	1	12 S	14 E	6/14/42	9,872	L. Miocene	
142	W. T. Burton...	State—Lake Pontchartrain No. 8		10 S	13 E	11/ 5/42	9,887	L. Miocene	
	Pointe Coupee Parish								
143	Humble Oil & Ref. Co.	Pointe Coupee Land & Improvement Co. No. 1	68	4 S	8 E	6/14/42	11,252	Wilcox	
	St. James Parish								
144	Cities Service Oil Co...........	B. F. Karstein No. 1	42	13 S	16 E	9/22/42	11,502	U. Miocene	St. James area
	St. Landry Parish								
145	Stanolind Oil & Gas Co.......	W. D. Haas No. 1	17	4 S	6 E	10/20/42	10,851	Wilcox	Palmetto area
146	Stanolind Oil & Gas Co.	R. L. Mills No. 1	14	7 S	3 E	2/28/42	10,350	L. Miocene	2½ miles E. production at Lewisburg
147	Sun Oil Co......	E. M. Boagni Est. No. 1	40	6 S	4 E	6/29/42	9,406	L. Miocene	
	St. Martin Parish								
148	The Texas Company	State-Lake Mongoulois No. 11		10 S	9 E	2/18/42	10,374	L. Miocene	S. flank Lake Mongoulois dome, 2 miles from production
	St. Mary Parish								
149	Danciger Oil & Ref. Co.	Adeline Sugar Factory No. 1	54	14 S	9 E	6/28/42	7,505	U. Miocene	
150	Danciger Oil & Ref. Co.......	Allain No. 1	46	13 S	9 E	7/17/42	4,505	U. Miocene	
151	The Texas Company	State-Cote Blanche Island No. 3		15 S	8 E	9/14/42	9,374	Salt	SE. flank Cote Blanche Island
	St. Tammany Parish								
152	J. Elliott Stanga.	Goodbee Estate No. 1	33	6 S	10 E	8/11/42	1,612	Pleistocene	
153	J. Elliott Stanga.	Stephenson & Watts No. 1	33	6 S	10 E	7/24/42	1,616	Pleistocene	
	Terrebonne Parish								
154	Gulf Refining Co., G.P.D.	J. Eschete No. 1	67	20 S	18 E	1/ 9/42	12,001	U. Miocene	One mile NW. production at Lapeyrouse
155	Humble Oil & Ref. Co.	Continental Land & Fur Co. No. B-1	31	17 S	14 E	9/ 7/42	11,343	U. Miocene	Turtle Bayou area
156	Pan-American Prod. Co.	Laterre Co., Inc. No. 1	67	18 S	18 E	4/27/42	10,502	U. Miocene	One mile NE. production at South Houma
	Washington Parish								
157	Humble Oil & Ref. Co.	Gaylord Container Corp. No. 1	25	2 S	12 E	8/24/42	7,570	Midway	

The Lake St. John field also produces from the Wilcox group. This field is the best discovery found anywhere in Louisiana during 1942. In addition to three sands which are productive of oil in the Wilcox, gas production is obtained from the Sparta sand. The lower part of the Upper Cretaceous group is productive of gas condensate. This is the first known occurrence of gas-condensate production in that section of the Upper Cretaceous in northeast Louisiana and should greatly encourage operators to find similar production in that part of the state.

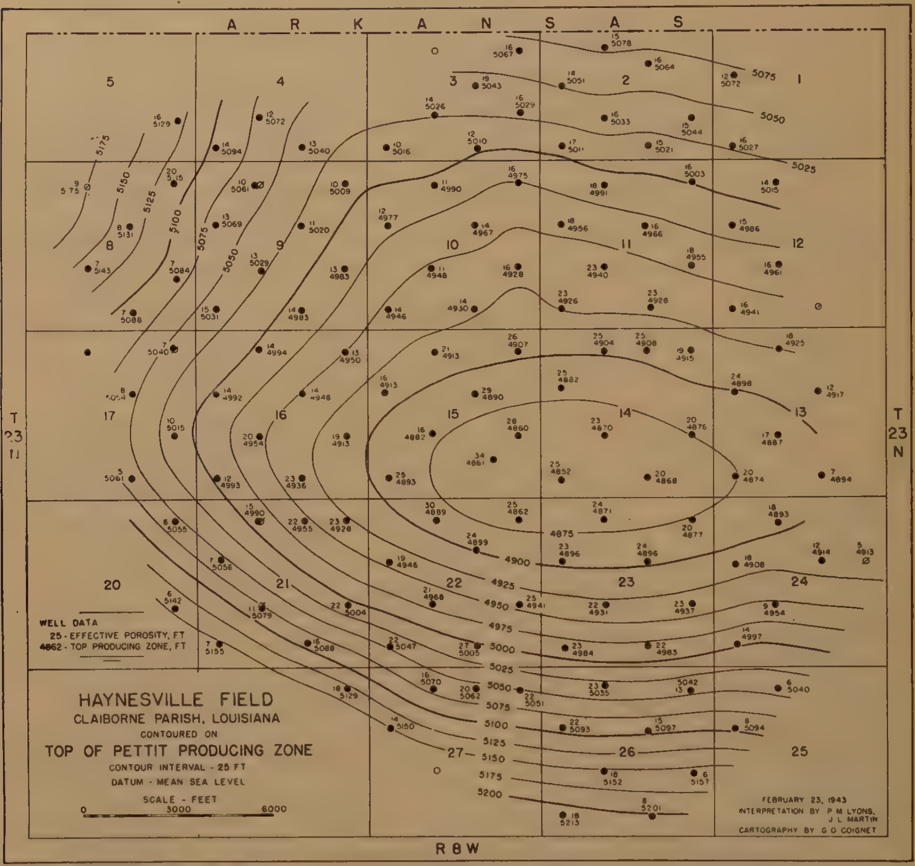

FIG. 1.—HAYNESVILLE FIELD, CLAIBORNE PARISH, LOUISIANA.

The discovery well in the Manifest field was completed in the Sparta formation as a pumper. The initial production was 79 bbl. of 20° A.P.I. gravity oil, of which approximately 30 per cent was base and sediment. Although numerous "shows" have been recorded from the Sparta in northeast Louisiana, this production is the first to be obtained from the Sparta in that part of the state. Offset wells drilled to the northwest and southwest of the discovery well were dry.

The discovery well of the North Carterville field, which was completed in the Pettit lime in the Sligo formation of Lower Cretaceous age, was a pumper. The second well to be completed in this field was completed for 176 bbl. per day of 38° A.P.I. gravity oil. The second well, like the first, made considerable quantities of fluid, which necessitated artificial lift. It was first thought that the North Carterville field might be another Haynesville (Pettit lime production). However, the available data indicate an effective porosity of approximately 10 ft. and a recovery of between 1000 and 1500 bbl. per acre.

The most active field in the state was the Haynesville field, Claiborne Parish, where 132 wells were drilled on 80-acre units for Pettit production during the past year. As a result, approximately 12,000 acres of production was proven up (Fig. 17).

The second most active field in the northern part of the state was the Nebo-Hemphill field in La Salle Parish, in which 72 wells were drilled for Wilcox production. Aside from the sands already producing at the first of the year in this field, four additional Wilcox sands and one Cockfield sand were found.

A total of 398 field wells were drilled in north Louisiana during 1942. Of this number, 275 found oil production, 49 found gas production, and 74 were dry. Some of these wells found new sands; others extended producing areas. A brief summary of the more important of these developments is listed below:

Bellevue, Bossier Parish.—Eagle Mills zone found at a depth of 8824 ft. subsea, indicating considerable uplift.

Grand Cane, De Soto Parish.—Production extended approximately one mile to the southwest; it may, however, be separate reservoir.

Haynesville, Claiborne Parish.—During the year, 132 wells were drilled, of which 124 flowed, three were put on pump, four were junked, and one was abandoned as dry. Pettit production proven to cover an area of approximately 12,000 acres. Pettit production defined on the east.

Indian Bayou, La Salle Parish.—Discovered in 1941. Already defined in east and west; only one well proven productive.

Larto Lake, Catahoula Parish.—Defined on all sides except east. Only one well proven productive.

Nebo-Hemphill, La Salle Parish.—Connection, both structurally and stratigraphically, between Nebo and Hemphill fields has been proved. The field has been gradually extended ½ mile to the north and approximately 1½ miles to the south. Production has been defined on all sides except the extreme northwest. Four new Wilcox sands proven productive, and one well completed in the Cockfield formation.

Olla, La Salle Parish.—Production more closely defined in the northwest, west and south. Only three wells drilled during the past year, all of which were dry.

Shreveport, Bossier and Caddo Parishes.—Production extended approximately ½ mile to the northeast.

South Jena, La Salle Parish.—Three wells defining production were drilled on the northeast and west sides of the field.

Sugar Creek, Claiborne Parish.—Oil production extended to southwest flank. One new Travis Peak sand proven productive.

Summerville, La Salle Parish.—Production gradually extended approximately ½ mile to the south and defined.

Trout Creek, La Salle Parish.—One new Wilcox sand proven productive; the northeastern isolated productive area (approx. 40 acres) fully defined on the northeast.

Willow Lake, Catahoula Parish.—Production defined on the north and south; field now covers an area of about 80 acres.

Zenoria-Little Creek, La Salle Parish.—Production defined on northwest and south flanks; one new sand proven productive. The Little Creek field was gradually extended to the northwest and merged with the Zenoria field.

NEW FIELDS, NEW SANDS AND EXTENSIONS IN SOUTH LOUISIANA DURING 1942

Eleven new fields were found in south Louisiana during 1942; five considered as oil fields, the remaining six as gas fields. These new discoveries are shown in the table on page 26.

Except for the Avery Island field, the Bayou Couba field, and the Bully Camp field, which are shallow, piercement-type salt domes, the structure of the other fields is apparently similar to the characteristic deep-seated salt-dome field so common in south Louisiana.

Field	Parish	Type of Production
Avery Island...	Iberia	Oil
Bayou Couba..	St. Mary	Oil
Branch........	Acadia	Oil
Bully Camp....	Lafourche	Gas
Deer Island....	Terrebonne	Gas
Freshwater Bayou.......	Vermilion	Gas
Hayes.........	Calcasieu	Gas
Krotz Springs..	St. Landry	Oil
Lake Decade.. .	Terrebonne	Oil
Rabbit Island..	Iberia	Gas
Thornwell.	Jefferson Davis	Gas

So far as potential reserves are concerned, none of these fields, except possibly the Branch field, would seem to suggest any reasonably large reserve at the present time. It is quite possible, of course, that fields such as Bayou Couba and the other piercement-type domes may ultimately prove to be similar in character to Anse La Butte, Jennings, or other well-known piercement-type domes in south Louisiana which have produced enormous quantities of crude oil, and which by no means have as yet exhausted their potentialities.

The most active field in south Louisiana was the Paradis field in St. Charles Parish. In addition to 30 wells completed as producers, three additional oil sands were discovered and put to production.

In the Ville Platte field, Evangeline Parish, 24 wells were completed as producers.

The Bayou Sale field, St. Mary Parish, was also active. Sixteen producers were completed, and a new shallow oil sand and a deep gas sand were found. The field was extended one mile to the east.

Salt was discovered in the Bay De Chene field, Lafourche Parish; the Lockport field, Calcasieu Parish; and the West Bay field, Plaquemines Parish.

Two new cycling projects have been established during the past year in south Louisiana—the Erath field, in Vermilion Parish, which is in process of construction, and the Bateman Lake field, St. Mary Parish, which is already in operation in a limited manner.

As in the previous year, most of the reserves in south Louisiana were found chiefly in discovering new sands and extending known producing sands in fields already in production. During the year, 359 field wells were drilled. Of this number, 278 were completed as oil wells, 26 as gas wells, and 55 were dry. In the process of drilling and completing these wells, 65 new oil and/or gas sands were found. Known producing areas were extended and in some cases delimited. The more important of these developments are listed briefly below:

Anse La Butte, Lafayette and St. Martin Parishes.—First production discovered on north flank of dome in new oil sand at 9800 ft. This is the first production in Lafayette Parish.

Barataria, Jefferson Parish.—Present production defined on southwest side.

Bastian Bay, Plaquemines Parish.—New oil sand, the second in the field, was discovered at 9300 ft. on the southwest flank. A 10,000-ft. test on the southwest flank 1800 ft. from production was abandoned as dry.

Bay De Chene, Jefferson and Lafourche Parishes.—Test located one mile east of discovery well, topped salt at 8634 ft.; first oil production from sand at 7500 ft. discovered on northeast flank of dome. Semiwildcat wells located on northwest and southeast flanks approximately one mile from discovery oil well were drilled to below 9000 ft. and were abandoned as dry.

Bayou Bleu, Iberville Parish.—Semiwildcat drilled one mile from production on the south side of dome was abandoned as dry in salt at 5148 feet.

Bayou des Allemands, Lafourche and St. Charles Parishes.—New oil-producing sands discovered at 5400, 9600 and 9900 ft. Semiwildcat 6000 ft. south of production was abandoned as dry at 10,702 feet.

Bayou Sale, St. Mary Parish.—New oil sand discovered at 4500 ft. and new gas sand at 10,700 ft. Production extended one mile to the east; also extended to south and west flanks and defined on north and northwest. Sixteen wells were completed in this field during the past year.

Black Bayou, Cameron Parish.—New oil sand discovered at 7800 feet.

Charenton, St. Mary Parish.—New oil sand discovered at 9200 ft. on south side of field.

Delta Duck, Plaquemines Parish.—Present production defined on northeast.

Delta Farms, Lafourche Parish.—New oil sand discovered at 9000 ft. Production extended ½ mile to northwest.

East White Lake, Vermilion Parish.—New oil sands discovered at 5900, 6800 and 10,040 ft. Field defined on northwest flank.

Erath, Vermilion Parish.—New gas-condensate sand discovered at 11,050 ft.; field defined on north. Agreement to cycle field was reached and plant construction is under way.

Gibson, Terrebonne Parish.—New gas sands discovered at 9200 and 10,300 feet.

Golden Meadow, Lafourche Parish.—Shallow production defined on southwest side. Production defined by deep test on south flank.

Grand Bay, Plaquemines Parish.—New oil sand discovered at 8750 ft. on southeast flank. New oil sand also discovered at 7400 ft. on southwest flank.

Gueydan, Vermilion Parish.—New oil sand found at 9500 ft. and new gas sand at 10,290 ft. Production extended on northeast flank.

Happytown, St. Martin Parish.—Production defined on west.

Horseshoe Bayou, St. Mary Parish.—New gas sands found at 10,200 and 11,250 ft. Field extended ½ mile to west and one mile to north.

Lafitte, Jefferson Parish.—New oil sand discovered at 8500 ft. Production extended ½ mile to northeast. Limited on east by semiwildcat one mile east of production.

Lake Chicot, St. Martin Parish.—New oil sands discovered at 7700 and 10,300 ft. Field extended in all directions.

Lake Decade, Terrebonne Parish.—Second well in field located ¼ mile west of discovery well was abandoned as dry at 13,075 feet.

Lake Hermitage, Plaquemines Parish.—Test on south flank of dome ½ mile from production abandoned as dry at 5505 feet.

Lake Long, Lafourche Parish.—Production defined on northwest by test abandoned as dry at 10,262 feet.

Lake Pelto, Terrebonne Parish.—New oil sands discovered on southeast flank at 7700, 9200 and 11,400 ft. Field extended ¾ mile to southeast.

Lake Salvador, Jefferson Parish.—Production defined on northwest flank by test abandoned as dry at 11,063 ft. Production extended in all other directions.

Lakeside (Lowry), Cameron Parish.—Present production extended ½ mile northwest.

Leeville, Lafourche Parish.—New oil sand discovered on southeast flank at 10,075 ft., extending production approximately one mile.

Lewisburg, Acadia and St. Landry Parishes.—Present production extended ½ mile to east. New gas sand found at 9000 ft. in well 1½ miles northeast of production.

Lockport, Calcasieu Parish.—New oil sand discovered at 6500 ft. Salt found at 8164 feet.

Neale, Beauregard Parish.—Deep Wilcox production extended 1½ miles southwest.

Paradis, St. Charles Parish.—Three new oil sands discovered at 10,400, 10,500 and 11,000 ft. Thirty producing wells completed, extending field ½ mile to southwest and ¼ mile to west and northwest.

Pecan Lake, Cameron Parish.—Present production defined on south flank.

Pine Prairie, Evangeline Parish.—Sparta production discovered on southeast flank at 9000 ft. and on southwest flank at 9450 ft. Cockfield production defined on east and southeast flanks, extended on south and west flanks.

Pointe au Fer, Terrebonne Parish.—New shallow gas sand discovered at 5600 ft., extending production ¾ mile to northeast. Production defined on north by test abandoned as dry at 11,047 feet.

Port Allen, West Baton Rouge Parish.—New oil sand discovered at 9100 ft., extending field one mile to east.

Port Barre, St. Landry Parish.—New oil sand discovered at 6600 ft. on northeast flank of dome. New oil sands also discovered at 5240 and 7460 ft. on southeast flank of dome.

Potash, Plaquemines Parish.—New oil sand discovered at 8700 ft. Test on northeast flank abandoned as dry at 8607 feet.

Raceland, Lafourche Parish.—Two new oil sands discovered at 8950 and 9250 feet.

Roanoke, Jefferson Davis Parish.—Production extended 2000 ft. to northwest.

Sorrento, Ascension Parish.—New gas-condensate sand discovered at 4100 ft. on northeast flank of dome.

South Houma, Terrebonne Parish.—New oil sand discovered at 10,160 feet.

Starks, Calcasieu Parish.—New oil sands discovered on northeast flank at 4600, 5350 and 6000 ft. First oil production discovered on southeast flank of dome from sand at 3900 feet.

Stella, Plaquemines Parish.—New oil sand discovered at 6300 ft. Production limited on northwest flank by two dry holes.

Sweet Lake, Cameron Parish.—New oil sand discovered at 6200 feet.

Unknown Pass, Orleans Parish.—Test 600 ft. east of production abandoned as dry at 5488 feet.

University, East Baton Rouge Parish.—New oil sands discovered at 9400 and 9700 ft. on south side of field.

Venice, Plaquemines Parish.—New oil sands discovered on north flank at 9250 ft. and on southwest flank at 10,970 feet.

Ville Platte, Evangeline Parish.—Present production partly defined on south and west flanks. Twenty-four wells completed as producers in the past year.

Vinton, Calcasieu Parish.—New oil sands discovered at 4900 ft. on north flank of dome and at 3300 ft. on southwest flank.

West Bay, Plaquemines Parish.—Salt discovered at 10,005 feet.

West Cote Blanche Bay, St. Mary Parish.—New oil sands discovered at 8000 and 8400 feet.

West Gueydan, Vermilion Parish.—New deep gas sand discovered at 10,780 ft. on north side of field.

West Hackberry, Cameron Parish.—New oil sand discovered at 8975 ft. on north flank of dome.

West Lake Verret, St. Martin Parish.—New oil sand discovered at 11,082 feet.

West Mermentau, Jefferson Davis Parish.—New oil sand found at 10,200 feet.

Wildcat Wells

During the year, 178 wildcat or exploratory wells were drilled; peculiarly enough, exactly the same number drilled during 1941. However, while 17 per cent of the wildcats were successful during 1941, only 11.4 per cent were successful during 1942 and such discoveries as were made were of considerably less importance as far as reserve is concerned. The picture for creating additional reserve, therefore, is not very encouraging. Undoubtedly it is true that it will be necessary to drill an increased number of wells in Louisiana in the future to maintain its reserve. However, in addition to increased wildcatting, it is also necessary to reexamine, both as to procedure and objective, the present programs of exploration in order to establish additional reserves. Many critics have said that the present methods of exploration are no longer effective. To a limited degree, this may be true. However, if complete use were made of all the geological and geophysical data and methods, and if effectively intercorrelated by the various technical branches of the industry, the percentage of successful wildcats undoubtedly would increase. The records of some companies already have proved that this would occur.

Although such a program would not be a complete solution of the problem, nevertheless it would improve the effectiveness of the present programs. The enormous amounts of data that have been compiled by various companies and agencies throughout the Gulf Coast, if carefully studied and correlated, should not only give rise to observations that have been overlooked but probably also will lead to new conclusions, which heretofore have not been contemplated.

During 1942, two shallow piercement-type salt domes were discovered in south Louisiana and two in north Louisiana. Forty-eight wells were drilled in search of Miocene production, 59 for Wilcox production, 17 for Upper Cretaceous production, 23 for Lower Cretaceous production, three for Jurassic production, and five were abandoned after setting surface casing.

Acknowledgments

The writer is indebted to Messrs. L. C. Aycock, P. M. Lyons and J. L. Martin, District Geologists of the Louisiana Geological Survey, for their assistance in compiling data used in this paper. Mr. H. W. Bell, Director, Division of Minerals, and Mr. W. H. Elliott, Statistician, Division of Minerals, kindly supplied figures on oil and gas production.

Oil and Gas Development in Michigan during 1942

By Theron Wasson,* Member A.I.M.E.

The year 1942 in Michigan was devoted largely to the development of fields discovered in 1941 but was also characterized by a great increase in prospecting for new productive horizons below the Dundee limestone. Some new fields were discovered but as yet these have shown few signs of being of major importance.

Michigan's total production for 1942, of 21,754,000 bbl. of oil, as reported by the U. S. Bureau of Mines, was second only to the record year of 1939 when 22,799,000 bbl. of oil were produced. All important fields were prorated throughout the year, and it is obvious that without proration a new all-time high would have been established for the state this year.

From 1925 to the end of 1942, Michigan has produced annually the following amounts of oil:

Year	Barrels	Source
1925	4,000	Michigan Geological Survey
1926	94,000	
1927	435,000	
1928	592,000	
1929	4,641,000	
1930	3,928,000	
1931	3,785,000	
1932	6,925,000	
1933	7,942,000	
1934	10,603,000	
1935	15,776,000	U.S. Bur. Mines, 1937
1936	11,928,000	U.S. Bur. Mines, 1938
1937	16,628,000	U.S. Bur. Mines, 1939
1938	19,211,000	U.S. Bur. Mines, 1938
1939	22,799,000	Amer. Petr. Inst. Quarterly
1940	19,764,000	
1941	16,361,000	
1942	21,754,000	
Total	183,170,000	

This tabulation shows the steady growth of the industry in Michigan since the first discovery of oil in 1925.

Maps

A map of the oil and gas fields of Michigan in 1941, published in the report for 1942, shows the main producing areas and should be referred to if information in regard to their location is desired.* The main producing zones were shown in the columnar section in the same publication.

Development in Fields

Reed City Field.—During 1942 the Reed City field, which ended 1941 with 112 producing oil wells, added 70 new producers to bring the total at the end of the year to 182 wells and 4700 proven acres. A south extension of the field developed during the year was in large part responsible for the increase. Approximately 9,000,000 bbl. of oil was produced from the field during the year, bringing the total accumulated production to the end of the year to roughly 11,750,000 barrels.

Headquarters Field.—The Headquarters field, which started the year with 10 producing oil wells, ended the year with 41 wells and 1240 proven acres. Approximately 2,300,000 bbl. of oil was produced in 1942.

Kawkawlin Field.—Although not a 1941 discovery, the Kawkawlin field has been actively developed on the 40-acre spacing plan during the last year, 42 producers having been completed, bringing the total number of wells at the end of the year to 77. Nearly 500,000 bbl. of oil was produced during the year.

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* "Petroleum Development and Technology," 1942, page 349.

TABLE 1.—*Oil and Gas Production in Michigan*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
1	Adams, *Arenac*	1937	1,030	0	2,595,237	1,043,959
2	Akron-Wisner, *Tuscola*	1936	0	0	134,220	42,962
3	Austin, *Mecosta*	1935	0	2,200	0	0
4	Bangor, *Van Buren*	1939	240	0	375,954	83,338
5	Beaverton, North, *Gladwin*	1935	360	0	650,395	23,396
6	South, *Gladwin*	1935	650	0	353,759	122,556
7	Bentley, *Gladwin*	1937	1,000	0	723,538	86,712
8	Birch Run, *Saginaw*	1934	300	0	199,093	8,866
9	Bloomingdale, *Van Buren*	1938	3,000	0	5,701,886	285,907
10	Broomfield-Deerfield, *Isabella*	1930	0	4,100	0	0
11	Buckeye, North, *Gladwin*	1936	2,900	0	14,700,381	393,165
12	South, *Gladwin*	1936	2,500	0	3,791,874	102,891
13	Clare (gas), *Clare*	1929	0	400	0	0
14	Clare City, *Clare*	1938	20	640	20,930	4,140
15	Clayton, *Arenac*	1936	1,300	560	3,653,744	191,746
16	Columbia, *Van Buren*	1938	1,230	0	1,964,715	101,208
17	Crystal, *Montcalm*	1935	2,180	200	7,211,544	59,225
18	Deerfield-Monroe, *Lenawee*	1935	260	0	303,572	66,594
19	Diamond Springs, *Allegan*	1938	560	0	752,706	42,872
20	Dorr, *Allegan*	1938	360	0	280,849	16,718
21	Edmore, *Montcalm*	1933	160	0	432,494	13,347
22	Edenville, *Midland*	1938	400	0	1,138,883	44,717
23	Evart, *Osceola*	1941 1942	800	2,080	198,192	198,192
24	Fork, *Mecosta*	1942	600	0	52,932	52,932
25	Freeman, *Clare*	1938	0	2,080	0	0
26	Gratiot, *Gratiot*	1927	0	400	0	0
27	Hart, *Oceana*	1932	180	0	116,275	0
28	Headquarters, *Clare, Roscommon*	1941	1,520	0	2,635,651	2,320,881
29	Home, *Montcalm*	1938	0	5,160	0	0
30	Kawkawlin, *Bay*	1938	6,400	160	719,786	493,030
31	Leaton, *Isabella*	1929	2,140	480	2,995,060	112,183
32	Lincoln, *Clare*	1938	0	2,720	0	0
33	Marion-Winterfield, *Osceola, Clare*	1940	1,320	10,400	2,368,668	1,258,946
34	Monterey, *Allegan*	1938	300	0	377,391	22,777
35	Mt. Pleasant, *Midland, Isabella*	1928	8,050	0	21,888,573	368,207
36	Muskegon, *Muskegon*	1927	2,700	*y*	6,712,363	26,144
37	Muskrat Lake, *Van Buren*	1941	1,050	0	215,810	103,401
38	New Haven, *Gratiot*	1935	0	2,400	0	0
39	Overisel, *Allegan*	1938	2,080	0	2,045,821	188,596
40	Porter-Yost, *Midland*	1931	8,440	0	39,415,691	1,222,422
41	Ravenna, *Muskegon*	1936	0	3,840	0	0
42	Reed City, *Osceola, Lake*	1941	5,000	4,320	11,858,290	9,102,008
43	Richfield, *Roscommon*	1941	480	0	72,352	70,775
44	Riverside, *Missaukee*	1940	0	2,560	0	0
45	Saginaw, *Saginaw*	1925	1,800	0	1,393,654	19,580
46	Salem, *Allegan*	1937	2,500	0	2,940,461	156,353
47	Salem (New), *Allegan*	1938	1,100	0	3,299,789	345,176
48	Sauble, *Lake*	1942	200	0	26,393	26,393
49	Sherman, *Isabella*	1936	1,220	0	4,068,365	168,347
50	Six Lakes, *Mecosta, Montcalm*	1934	0	10,280	0	0

[b] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
	To End of 1942	During 1942	Completed to End of 1942	During 1942		End of 1942			Number of Wells		Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
				Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift					
1	0	0	79	25	1	0	58	0	9	49	y	y	0	Traverse 37.0 Dundee 34.3	y 1.56
2	0	0	17	5	2	0	10	0	0	10	y	y	0	43.2 42.6	y
3	5,759	0	29	0	0	11	0	0	0	0	512	y	0	0	0
4	0	0	25	7	2	0	15	0	0	15	y	y	0	28.5	y
5	0	0	28	0	0	0	13	0	0	13	y	y	0	41.3	0.16
6	0	0	21	5	1	0	20	0	0	20	y	y	0	41.3	0.16
7	0	0	41	1	0	0	37	0	0	37	y	y	0	41.4	y
8	0	0	28	0	0	0	25	0	0	25	y	y	0	42.4	0.25
9	0	0	243	0	9	0	95	0	0	95	y	y	0	41.2	0.51
10	7,910	874	62	2	0	0	0	53	0	0	580	y	0	0	0
11	0	0	264	2	13	0	169	0	0	169	y	y	0	39.0	0.25
12	0	0	188	0	4	0	84	0	0	84	y	y	0	39.0	0.25
13	1,146	101	9	0	0	0	0	7	0	0	y	328	0	0	0
14	713	1	8	0	1	0	2	6	0	2	605	y	0	30.5	0.40
15	3,336	816	90	2	3	0	44	28	0	44	620	y	0	34.3	y
16	0	0	103	0	3	0	53	0	0	53	0	0	0	39.2	0.57
17	420	57	241	0	4	0	19	6	0	19	y	y	0	45.2	y
18	0	0	31	1	2	0	23	0	0	23	0	0	0	40.0	y
19	0	0	55	0	0	0	23	0	0	23	y	y	0	y	y
20	0	0	26	0	0	0	19	0	0	19	0	0	0	41.4	0.44
21	105	2	13	0	0	0	5	0	0	5	0	0	0	43.2	0.11
22	0	0	35	0	0	0	26	0	0	26	0	0	0	41.3	y
23	30	30	26	24	0	0	13	1	10	3	y	y	0	46.0	y
24	0	0	3	3	0	0	3	0	3	0	0	0	0	y	y
25	1,332	433	16	2	0	0	0	15	0	0	607	523	0	0	0
26	0	0	3	0	0	0	0	0	0	0	x	x	0	0	0
27	0	0	17	0	0	0	0	0	0	0	0	0	0	34.0	y
28	0	0	41	31	0	0	41	0	36	5	0	0	0	T. 40.6 D.R. 48.9	0.16 1.42
29	3,644	1,120	25	1	0	0	0	22	0	0	515	y	0	0	0
30	y	y	78	42	0	0	77	0	0	77	y	y	0	34.9	0.37
31	186	0	93	1	0	0	46	0	0	46	y	y	0	43.0	0.16
32	2,454	926	15	0	0	0	0	13	0	0	607	522	0	0	0
33	3,244	2,667	120	45	4	0	38	58	6	32	y	y	0	44	0.5
34	0	0	28	0	2	0	17	0	0	17	0	0	0	37.6	y
35	5,380	232	447	3	5	0	181	0	0	181	0	0	0	41.5	0.13
36	7,874	69	412	0	0	0	26	8	0	26	0	0	0	37.4	0.56
37	0	0	52	11	9	0	44	0	0	44	0	0	0	y	y
38	4,504	1,267	53	0	0	0	0	48	0	0	448	y	0	0	0
39	0	0	155	0	12	0	96	0	0	96	0	0	0	39.4	0.50
40	2,523	0	536	0	8	0	326	0	0	326	0	0	0	41.3	0.26
41	1,276	119	29	0	0	0	0	26	0	0	720	y	0	0	0
42	3,163	2,539	211	73	3	0	182	29	139	43	y	y	0	45	0.6
43	0	0	11	10	0	0	11	0	11	0	0	0	0	y	y
44	122	8	13	4	0	0	0	13	0	0	y	y	0	0	0
45	0	0	282	0	0	0	55	0	0	55	0	0	0	44.3	0.24
46	51	18	205	0	7	0	157	0	0	157	0	0	0	41.0	0.6
47	0	0	104	0	3	0	84	0	0	84	0	0	0	41.0	0.56
48	0	0	5	5	0	0	5	0	0	5	0	0	0	y	y
49	0	0	96	0	3	0	58	0	0	58	0	0	0	47.8	y
50	30,629	4,129	247	1	0	0	0	187	0	0	516	y	0	0	0

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
1	Traverse Dundee	Dev	Lime Dol. Lm.	P	2,031 2,841	2,039 2,941	15 16	A	Sylvania	4,950
2	Dundee Detroit River	Dev	Lime Dol. Lm.	P	2,840 3,371	2,860 3,423	5 13	A	Sylvania	3,978
3	Stray-Marshall	Mis	Sand	P	1,390	1,410	10	A	Detroit River	4,042
4	Traverse	Dev	Lime	P	1,002	1,006	2	A	Traverse	1,248
5	Dundee	Dev	Lime	P	3,880	3,895	12	A	Dundee	4,029
6	Dundee	Dev	Lime	P	3,880	3,895	12	A	Lw. Detroit River	4,977
7	Dundee	Dev	Lime	P	3,500	3,536	25	A	Sylvania	5,115
8	Berea	Mis	Sand	P	1,529	1,546	13	A	Dundee	2,760
					1,216	1,219	2.5			
9	Traverse	Dev	Lime	P	1,277	1,279	1.5	A	Detroit River	1,904
10	Stray-Marshall	Mis	Sand	P	1,300	1,350	5	A	Detroit River	4,031
11	Dundee	Dev	Lime	P	3,621	3,646	11	A	Detroit River	4,696
12	Dundee	Dev	Lime	P	3,574	3,597	11	A	Detroit River	4,330
13	Stray-Marshall	Mis	Sand	P	1,408	1,413	5	A	Detroit River	4,055
14	Stray-Marshall	Mis	Sand	P	1,283	1,293	6.5	A	Dundee	3,865
15	Oil—Dundee Gas—Berea	Dev Mis	Lime Sand	 P	2,534 1,166	2,576 1,189	12 12	A	Sylvania	4,163
16	Traverse	Dev	Lime	P	1,190	1,193	2.5	A	Detroit River	1,904
17	Stray-Marshall Dundee	Mis Dev	Sand Lime	 P	1,016 3,191	1,024 3,202	4 4	A	Detroit River	3,520
18	Trenton	Ord	Lime	P	2,102	2,114	9.	MF	St. Peter	3,088
19	Traverse	Dev	Lime	P	1,466	1,472	3.5	A	Traverse	1,571
20	Traverse	Dev	Lime	P	1,596	1,607	4	A	Niagaran	3,319
21	Traverse	Dev	Lime	P	3,108	3,112	4	A	Dundee	3,700
22	Dundee	Dev	Lime	P	3,788	3,796	8	A	Dundee	4,015
23	Stray-Marshall Dundee	Mis Dev	Sand Lime	 P	1,395 3,753	1,467 3,760	15 7.5	A	Detroit River	4,457
24	Dundee	Dev	Dol	P	3,817	3,821	2.5	A	Dundee	4,013
25	Stray-Marshall	Mis	Sand	P	1,486	1,512	12	A	Detroit River	3,957
26	Parma	Pen	Sand	P	500	510	10	A	Dundee	3,100
27	Traverse	Dev	Lime	P	1,880	1,890	4	A	Dundee	2,436
28	Traverse Detroit River	Dev	Lime Dol	P	3,285 3,838	3,453 3,857	5 13	A	Sylvania	5,631
29	Stray-Marshall	Mis	Sand	P	1,390	1,400	7.5	A	Dundee	3,565
30	Dundee	Dev	Lime	P	2,846	2,906	35.8	A	St. Peter	10,447
31	Stray-Marshall Dundee	Mis Dev	Sand Lime	 P	1,239 3,634	1,243 3,681	4 7.5	A	Dundee	3,594
32	Stray-Marshall	Mis	Sand	P	1,526	1,538	10	A	Detroit River	4,285
33	Stray-Marshall Traverse Dundee Sylvania	Sand Lime Lime Dol. Sd.	Mis Dev Dev Dev	 P P 	1,392 3,140 3,743 5,014	1,408 3,156 3,770 5,058	9 5 3 6	A	Lower Detroit River	5,100
34	Traverse	Dev	Lime	P	1,638	1,647	3	A	Traverse	1,808
35	Dundee	Dev	Lime	P	3,536	3,568	14.6	A	Sylvania	4,821
36	Traverse Dundee	Dev	Lime	P	1,682 2,050	1,687 2,075	3.5 10	A	St. Peter	4,754
37	Traverse	Dev	Lime	P	1,283	1,284	1.5	A	Traverse	1,332
38	Stray-Marshall	Mis	Sand	P	915	950	5	A	Dundee	3,536
39	Traverse	Dev	Lime	P	1,471	1,481	3	A	Detroit River	1,972
40	Dundee	Dev	Lime	P	3,422	3,434	12	A	Sylvania	4,733
41	Berea	Mis	Dol Sand	P	1,212	1,233	10	y	Dundee	2,306
42	Stray-Marshall Traverse Dundee Detroit River	Mis Dev Dev Dev	Sand Lime Lime Dol	P	1,210 2,935 3,492 3,540	1,218 2,964 3,518 3,592	5 5 3 7	A	Lower Detroit River	4,333
43	Detroit River	Dev	Dol	P	4,191	4,206	8	A	Sylvania	4,440
44	Stray-Marshall	Mis	Sand	P	1,331	1,355	15.7	A	Dundee	3,945
45	Berea	Mis	Sand	P	1,820	1,850	16	A	Sylvania or Bass Island	3,985
46	Traverse	Dev	Lime	P	1,587	1,601	8	A	Trenton	3,792
47	Traverse	Dev	Lime	P	1,621	1,631	6	A	Detroit River	1,968
48	Traverse	Dev	Lime	P	2,134	2,135	1.5	A	Sylvania	3,765
49	Dundee	Dev	Dol. Ls.	P	3,648	3,652	4	A	Detroit River	4,031
50	Stray-Marshall	Mis	Sand	P	1,275	1,300	16	A	Detroit River	3,790

NEW DISCOVERIES IN 1942

Richfield Pool, Roscommon County.—Actually discovered in August 1941, this field had only one well and had produced only 1577 bbl. to the end of that year. During 1942 ten more wells were drilled and about 70,000 bbl. of oil was produced. Production is from a low-sulphur oil zone near the base of the Detroit River formation at a depth of approximately 4200 feet.

Evart, Osceola.—The Evart field was discovered May 1, 1942. By the end of the year 13 wells had been completed and, roughly, 1200 acres appeared to be proved, Production is from the Dundee limestone at a depth of 3800 ft. About 175,000 bbl. of oil was produced during the year.

Fork, Mecosta.—The Fork pool, also called the Barryton pool, was discovered Sept. 5, 1942. Three wells had been com-

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
51	Tallmadge (South), *Kent*	1939	680	320	297,133	87,481
52	Temple, *Clare*	1938	2,710	0	13,027,346	869,700
53	Trowbridge, *Allegan*	1941	1,280	0	139,169	55,283
54	Vernon, *Isabella*	1930	1,100	880	4,391,932	97,466
55	Walker, *Kent*	1938	5,700	0	9,010,073	678,879
56	West Branch, *Ogemaw*	1933	5,000	0	4,889,740	333,181
57	West Hopkins, *Allegan*	1941	480	0	310,652	223,299
58	Winfield, *Montcalm*	1938	80	2,580	47,438	7,256
59	Wise, *Isabella*	1938	1,200	960	1,729,083	225,251
60	Wyoming Park, *Kent*	1939	450	0	102,239	13,775
61	Miscellaneous				1,035,158	165,582
62	Total		85,010	59,720	183,367,254	21,747,815

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
				During 1942		End of 1942			Number of Wells						
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
51	99	99	61	3	0	0	53	2	0	53	y	y	0	42	y
52	1,956	275	166	0	15	0	115	0	0	115	0	0	0	43.8	0.37
53	0	0	34	13	5	0	32	0	0	32	0	0	0	y	y
54	1,416	22	94	1	2	0	35	5	0	35	575	y	0	44.1	0.3
55	3,706	642	493	5	16	0	153	6	0	153	0	0	0	42.1	0.4
56	0	0	258	1	0	0	233	0	0	233	0	0	0	33.4	0.35
57	0	0	31	14	0	0	31	0	0	31	0	0	0	41.5	y
58	1,979	546	21	4	0	0	4	16	0	4	446	368	0	y	y
59	567	259	68	0	0	0	60	6	0	60	y	y	0	47.0	y
60	0	0	21	0	0	0	13	0	0	13	0	0	0	41.5	y
61	4,502	497	135	17	3	0	62	21	0	62					
62	100,026	17,748	6,341	364	142	11	2,991	576	214	2,777					

pleted by the end of the year and at least 600 acres appeared to be proved. Some 50,000 bbl. of oil was produced during the year.

DEEP TESTING

Deep testing in Michigan has been growing steadily for the past two or three years as the result of repeated showings of gas and oil in two horizons in the lower part of the Detroit River formation. Small commercial production of high-sulphur oil was developed several years ago in Tuscola County, and later one well produced this oil commercially for a year before deepening on the Kawkawlin structure. Similar oil has been produced for more than a year from one well on the west flank of the Adams structure. These occurrences were considered significant but the high sulphur content of the oil discouraged prospecting. The Richfield, Roscommon, discovery in 1941, however, proved the presence of oil at a lower stratigraphic depth and caused an increased interest in prospecting to this zone. During 1942 many counties in Michigan, particularly Arenac, Ogemaw, Roscommon, and Clare, received a number of these tests. Encouraging showings were encountered in many wells and several small commercial wells completed. Most important of these was The Pure Oil Company's discovery on the Winterfield structure, which has been flowing at approximately 100 bbl. per day since completion on Sept. 4, 1942. This well produces high-gravity low-sulphur oil from a zone comparable to that producing in the Richfield pool. Other small producers from this zone were completed in the Adams field but most of these are being abandoned as noncommercial. In the Headquarters field two wells have produced at approximately 50 bbl. per day from the overlying sulphur oil zone.

EXPLORATION

Exploration in the Lower Peninsula of Michigan was almost entirely by shallow testing to geological markers in the bedrock beneath the drift. Major companies operating in Michigan drilled 187 shallow tests during the year for information of this kind. As far as is known, geophysical work, which in past years has been carried on in an experimental way, was not done in Michigan this year.

PRICES

Prices have remained essentially unchanged throughout the year. As the result of price freezing, Midland grade crude was

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
51	Traverse	Dev	Lime	P	1,820	1,845	7.5	A	Traverse	2,030
52	Monroe	Dev	Dol	P	3,895	3,900	4.5	A	Detroit River	4,159
53	Traverse	Dev	Lime	P	1,350	1,354	2	A	Detroit River	1,645
54	Dundee	Dev	Dol. Ls.	P	3,741	3,743	3	A	Dundee	3,899
55	Traverse	Dev	Lime	P	1,827	1,847	6	A	St. Peter	5,222
56	Traverse, Dundee	Dev	Lime	P	1,880 2,622	1,910 2,707	5 20	A	Salina	5,405
57	Traverse	Dev	Lime	P	1,587	1,598	2	A	Traverse	1,633
58	Stray-Marshall Detroit River	Mis Dev	Sand Dol	 P	1,124 3,355	1,141 3,356	8 1	A	Detroit River	3,374
59	Dundee	Dev	Lime	P	3,702	3,716	10.5	A	Dundee	3,854
60	Traverse	Dev	Lime	P	1,191	1,218	6	A	Detroit River	2,255
61										
62										

sold for $1.44 per barrel; Sherman grade for $1.39. The only rise in price was an increase for the Adams field, Arenac County, from $1.27 to $1.42 per barrel, on March 30, 1942.

ACKNOWLEDGMENTS

Mr. Carl C. Addison, Division Geologist of The Pure Oil Co. at Saginaw, Mich., and Mr. D. C. Shackelford, Chief Scout of that company, assisted in the preparation of this report. Miss Lou Williams and Mr. C. K. Clark, of the Pure Oil Co., gave particular attention to the tabulated data. As in the past, the State Geological Survey of Michigan has furnished information on oil and gas production.

TABLE 2.—*Summary of Drilling Operations in Michigan*

Important Wildcats Drilled in 1942
Surface Formation, Pleistocene

	County	Location			Total Depth, Ft.	Deepest Horizon Tested	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Remarks
		Sec.	Tp.	Rge.				Oil, U. S. Bbl.	Gas, Millions Cu. Ft.		
1	Arenac	36	19 N	3 E	4,229	Detroit River	Erwin Major	732			This well was first to encounter oil pay in Detroit River in Adams field
2	Allegan	29	4 N	12 W	3,319	Upper Salina	Muskegon Oil Co.	45			Discovery of new producing zone in Salina in Dorr field
3	Barry	10	3 N	9 W	5,121	St. Peter	Sun Oil Co.	Dry			This well contributed to stratigraphy of Barry County. Deep test
4	Clare	30	20 N	6 W	5,100	Sylvania	Pure Oil Co.	257			This well discovered new producing zone in Winterfield-Marion field
5	Lake	16	19 N	14 W	2,114	Traverse	Wm. P. Shoemaker	316			Discovery well of field in Sauble township, Lake County
6	Lake	11	20 N	14 W	3,938	Detroit River	Ohio Oil Co.	Dry			First deep test in relatively unknown area
7	Mecosta	5	16 N	7 W	3,818	Dundee	Sun Oil Co.	519			Discovery well of Fork field
8	Missaukee	11	23 N	5 W	4,596	Detroit River	Sun Oil Co.	1,200			First well to discover oil in Dundee formation in Enterprise township
9	Missaukee	11	24 N	5 W	4,524	Detroit River	Sun Oil Co.	16			Discovery well of Norwich field
10	Missaukee	26	22 N	6 W	3,845	Dundee	Gordon Oil Co.	187			Discovery of oil in Aetna township which will possibly lead to development of field
11	Ogemaw	33	24 N	2 E	5,367	Sylvania	A. Weber & Assoc.	15			Discovery of oil in Detroit River north of West Branch field
12	Osceola	23	18 N	8 W	3,778	Dundee	Sun Oil Co.	360			Discovery well of Evart field
13	Roscommon	29	21 N	3 W	4,963	Sylvania	E. Hilliard	50			Discovery of oil in Detroit River formation in Headquarters field
14	Van Buren	9	2 S	16 W	1,018	Traverse	Fisher McCall Oil & Gas Co.	60			Discovery well of North Bangor field

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	27	18
Number of oil wells completed during 1942	283	10
Number of gas wells completed during 1942	69	6
Number of dry holes completed during 1942	82	226

Oil and Gas Development in Mississippi during 1942

By H. M. Morse*

During the year 1942 there were 66 wildcats drilling in Mississippi. One cored in oil sand, the Macro Drilling Company's Longbell No. 1 in Clarke County, but as yet it has not succeeded in recovering the oil.

These drillings brought to light five salt domes, two of which had heavy oil showing; one drilled by the Magnolia Petroleum Co. in Warren County, and

Table 1.—*Oil and Gas Production in Mississippi*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells					
										During 1942		End of 1942		
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]
1	Tinsley, *Yazoo*	1939	9,840	*x*	47,781,794	28,177,484	*x*	*x*	359	6	1	1	339	*x*
2	Vaughn-Pickens, *Yazoo and Madison*	1940	40	*x*	662,443	126,190	*x*	*x*	9	0	1	*x*	2	*x*
3	Jackson, *Hinds and Rankin*	1930	*x*	7,500	*x*	*x*	112,460,152	2,084,061	218	1	0			23
4	Pickens-Sharpsburg, *Madison and Yazoo*	1941	320	*x*	311,389	303,636	*x*	*x*	8	6	2	*x*	8	*x*
5	Cary, *Sharkey*	1941	160	*x*	10,503	6,925	*x*	*x*	4	2	2		2	*x*

Line Number	Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells										Depth, Avg. Ft.					
	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	40	289	*x*	*x*	0	49.6-31.6	Selma, Eutaw, Tuscaloosa	Cre	*x*	*x*	4,378	5,834		FD	Tuscaloosa	6,540
2	0	2					Eutaw	Cre	39.9		4,865					
3							Selma	Cre	Gas	*x*	2,420	2,435		D	Trinity	5,529 CreL
4	0	8	0	0	0	39.9	Eutaw	Cre			4,830	4,850	18	A	Tuscaloosa	5,658
5	0	2	*x*	*x*	*x*	24.8	Selma chalk	Cre			3,270	3,275	5		Cretaceous	3,275

[b] Footnotes to column heads and explanation of symbols are given on page 264.

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* State Oil and Gas Supervisor, Jackson, Miss.

one by the Freeport Sulphur Co. in Lincoln County.

The deepest well commenced in the Upper Cretaceous and penetrated the Devonian undifferentiated. The deepest well as to total depth was drilled by the Amerada Petroleum Co. in Franklin County, which reached the total depth of 11,802 ft. and bottomed in Glen Rose of the Cretaceous age.

Tinsley Oil Field, Yazoo County.—The Tinsley oil field, its boundaries fairly defined, had six oil wells and four dry holes drilled in 1942.

Vaughan-Pickens Oil Field, Yazoo County. The Vaughan-Pickens field was inactive on drilling and had one abandonment.

Cary Oil Field, Sharkey County.—The British-American Oil Co. drilled two wells, one producer and one dry hole.

Pickens-Sharpsburg Oil Field, Madison and Yazoo Counties.—The Pickens-Sharpsburg field had the greatest extension for the year, with six oil wells and one dry hole. Only one or two more locations need be drilled before this field and the Vaughan-Pickens field will connect.

PROSPECTS FOR 1943

The advanced drilling information indicates that Mississippi will have at least 90 to 100 wildcat wells drilling during 1943. For better correlation purposes, at least one thousand more dry holes are needed.

TABLE 2.—*Summary of Drilling Operations in Mississippi*

Important Wildcats Drilled in 1942

	County	Location			Total Depth, Ft.	Deepest Horizon Tested	Drilled by	Remarks
		Sec.	Tp.	Rge.				
1	Adams	36	6 N	2 W	7,534	Midway Eoc	H. W. Elliott	Dry hole
2	Chickasaw	29	12 S	5 E	3,494	Ft. Payne Mis	Carter Oil Co.	Dry hole
3	Claiborne	25	11 N	3 E	6,999	Midway Eoc	Amerada	Dry and abandoned
4	Clarke	10	2 N	16 E	3,687	Eutaw Cre	Macro Drill. Co.	Oil, salt water and sand
5	Forrest	35	1 S	13 W	5,285	Midway Eoc	Placid Oil Co.	Dry and abandoned
6	Franklin	10	7 N	3 E	11,802	Glen Rose Cre	Amerada	Dry and abandoned
7	Harrison	33	4 S	11 W	8,974	Tuscal. Cre	Humble Oil & Ref. Co.	Dry and abandoned
8	Hinds	12	6 N	4 W	8,990	Tuscal. Cre	Tide Water	Dry and abandoned
9	Issaquena	17	17 N	3 E	6,509	Tuscal. Cre	Pres Cochrane	Dry and abandoned
10	Jones	12	7 N	14 W	8,878	Tuscal. Cre	A. H. & C. L. Rowan	Dry and abandoned
11	Lamar	30	1 N	16 W	6,024	Midway Eoc	Placid Oil Co.	Dry and abandoned
12	Madison	14	11 N	3 E	5,850	Tuscal. Cre	Carter Oil Co.	Dry and abandoned
13	Pearl River	15	4 S	16 W	6,134	Wilcox Eoc	Placid Oil Co.	Dry and abandoned
14	Scott	32	5 N	7 E	7,313	Tuscal. Cre	Carter Oil Co.	Dry and abandoned
15	Sharkey	19	11 N	7 W	4,022	Cre	Johnston & Cook	Dry and abandoned
16	Simpson	5	2 N	4 E	10,405	Tuscal. Cre	Gulf Refining Co.	Dry and abandoned
17	Stone	32	3 S	10 W	8,575	Tuscal. Cre	Harry I. Morgan	Dry and abandoned
18	Sunflower	36	18 N	5 W	5,707	Tuscal. Cre	Ohio Oil Co.	Dry and abandoned
19	Warren	36	18 N	4 E	6,953	Selma Cre	Roy Lee, Trustee	Dry and abandoned
20	Wilkinson	10	3 N	1 E	7,504	Wilcox Eoc	Bering Oil Co.	Dry and abandoned
21	Yazoo	3	9 N	1 W	7,016	Tuscal. Cre	Charles A. Perkins	Dry and abandoned

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	20	66
Number of oil wells completed during 1942	14	
Number of gas wels completed during 1942	1	
Number of dry holes completed during 1942	6	

Development of Oil and Gas in Missouri in 1942

By Frank C. Greene*

The principal event in the development of oil and gas in Missouri in 1942 was the drilling of the Cities Service Oil Company's No. 1 Jim Cook, in the northwest corner, NW. ¼ sec. 32, T. 65 N., R. 39 W., Atchison County, in the northwest corner of Missouri. This well, not yet completed, bailed several barrels of free oil in about 27° Baumé from a sand called the Bartlesville by those in charge, at a depth of 1450 ft. The well is on a block of leases obtained after the area, which is covered by several hundred feet of glacial drift, had been prospected by core drilling.

Earlier in the year the same company drilled a well on the Glen Gray farm in the southwest corner, SW. ¼ sec. 29, T. 65 N., R. 39 W., to a depth of 2427 ft. in the Hunton lime with a rotary drill. Oil stains in this hole led to the drilling of the second well.

Table 1.—*Wells Drilled for Oil and Gas in Missouri in* 1942

County	Number of Oil Wells	Number of Gas Wells	Dry
Andrew			1
Atchison			1
Bates		2	6
Caldwell		1	3
Cass			1
Clinton			2
Holt			1
Jackson	1		1
Knox			1
Nodaway			1
Platte		4	4
Ray			5
Sullivan			1
Totals	1	7	28

Otherwise drilling in Missouri was uneventful, with a total of only 36 completions, of which one was a very small oil well, seven were small gas wells and 28 were dry holes. The total footage drilled was 24,754½ ft., of which 14,028½ was by cable tools and 10,726 ft. by rotary. Twelve of the dry holes were drilled into Mississippian or older beds. Table 1 gives a summary of activities by counties.

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Petroleum Development in Nebraska in 1942

By E. C. Reed*

DRILLING operations in Nebraska during 1942 were reduced to approximately 50 per cent of the previous year's record. Forty-one wells were completed during the year, 15 of them resulting in oil production.

No new fields were discovered, but the Barada field was extended and developed. Deeper drilling in the Dawson field was disappointing in view of the high expectations held for the Viola, but some small Viola production did result, the first from

TABLE 1.—*Oil and Gas Production in Nebraska*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells		
			Oil	To End of 1942	During 1942	Completed to End of 1942	During 1942: Completed	End of 1942: Producing Oil[c]
1	Barada, *Richardson*	1941	300	407,700	373,300	15	9	15
2	Dawson, *Richardson*	1940	140	17,800	14,000	7	5	7
3	Falls City, *Richardson*	1939	1,080	2,912,000	863,850	56	1	54
4	Shubert, *Richardson*	1940	400	102,100	25,000	10	0	10
5	Total		1,920	3,439,600	1,276,150	88	15	86

Line Number	Oil-production Methods, End of 1942: Number of Wells: Artificial Lift	Character of Oil: Gravity A.P.I. at 60°F., Weighted Average	Producing Formation								Deepest Zone Tested to End of 1942	
			Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.: Top Prod. Zone	Depth, Avg. Ft.: Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	15	29.6	Hunton	Dev	D	Cav	2,403	2,481	78	A	Hunton	2,517
2	7	21.7	Hunton and Viola	Dev and Ord	D	Cav	2,224 2,897	2,249 2,901	25 4	A A	Granite (1937)	3,424
3	54	31.5	Hunton	Dev	D	Cav	2,250	2,273	23	A	Arbuckle	3,372
4	10	31	Hunton	Dev	D	Cav	2,495	2,518	23	N.T.	Hunton	2,638
5	86											

[b] Footnotes to column heads and explanation of symbols are given on page 264.

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TABLE 2.—*Summary of Drilling Operations in Nebraska*

Important Wildcats Drilled in 1942

	County	Location			Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Initial Production per Day	Pressure, Lb. per Sq. In.	Remarks
		Sec.	Tp.	Rge.					Oil, U. S. Bbl.	Tubing	
1	Adams	S_2 SE SW 35	5 N	9 W	4,125	Pleistocene	Pre-Cambrian	Ohio Oil Co.			Dry and abandoned
2	Adams	C NW NE 18	6 N	12 W	2,430	Pleistocene	Permian	L. D. Essinger			Dry and abandoned
3	Antelope	NE NE SW 31	25 N	6 W	Drilling	Recent		Forrest Cave et al.			Drilling
4	Butler	C SE NW 29	16 N	2 E	Drilling	Recent		Bellwood Syndicate			Drilling
5	Dawes	C NW SW 1	33 N	50 W	Drilling	Cretaceous-Pierre		Chadron Oil & Gas Co.			Drilling
6	Gage	SW SW SW 14	1 N	6 E	2,775	Permian	Pre-Cambrian	Don Linn et al.			Dry and abandoned
7	Gage	SW SW 2	4 N	6 E	1,106	Pleistocene	Pennsylvanian	S. F. Miller et al.			Dry and abandoned
8	Gage	NW SW SE 27	2 N	7 E	1,975	Permian	Pre-Cambrian	Gage Co. Dev. Co.			Dry and abandoned
9	Greeley	SE SW NE 28	17 N	12 W	3,454	Pleistocene	Arbuckle (Camb.)	Henry Bredthauer et al.			Dry and abandoned
10	Hall	SW SW SW 11	12 N	11 W	3,500	Pleistocene	Arbuckle	Nebr. Wyo. Oil Co. et al.			Dry and abandoned
11	Harlan	C NE NW 28	2 N	18 W	3,933	Pleistocene	Arbuckle	Ohio Oil Co.			Dry and abandoned
12	Lincoln	NW NW 16	9 N	33 W	4,633	Pleistocene	Pre-Cambrian	Texon Royalty Co.			Dry and abandoned
13	Lincoln	C NW NW 16	12 N	26 W	3,425	Quaternary	Pre-Cambrian	Parker Drilling Co.			Dry and abandoned
14	Nemaha	SE SW 21	6 N	13 E	3,026	Permian	Pre-Cambrian	M. J. Sullivan et al.			Dry and abandoned
15	Nemaha	SE NE NE 34	6 N	15 E	3,515	Quaternary	Pre-Cambrian	Gulf Oil Co.			Dry and abandoned
16	Pawnee	SE SE 13	1 N	12 E	539	Recent on Penn.	Pre-Cambrian	B. E. Thorne et al.			Dry and abandoned
17	Richardson	NE NE NE 29	2 N	13 E	1,822	Pennsylvanian	Pre-Cambrian	E. H. Towle et al.			Dry and abandoned
18	Richardson	C E_2 SE SE 3	1 N	14 E	2,889	Permian	Viola	Skelly Oil Co.	14-15	[a]	Small producer
19	Richardson	E_2 SE NE 4	1 N	14 E	3,057	Permian	Viola	Weekes, Clampitt, Brown	64	[a]	40 per cent water. Hunton production
20	Richardson	E_2 SE SW 4	1 N	14 E	?	Permian	Hunton	Towle et al.			Dry and abandoned
21	Richardson	E_2 NE SE 9	1 N	14 E	2,300	Permian	Hunton	August Krueger et al.	25	[a]	67 per cent water
22	Richardson	E_2 SW NW 10	1 N	14 E	2,952	Permian	Viola	Powers Oil Co.	25	[a]	97 per cent water
23	Richardson	E_2 NW SE 10	1 N	14 E	3,289	Permian	St. Peter (Wilcox?)	Skelly Oil Co.	3½ 22 hr.	[a]	127 bbl. water per 22 hr. Viola production
24	Richardson	W_2 SW SE 24	1 N	15 E	920	Permian	Pennsylvanian	S. J. Brown et al.			Dry and abandoned
25	Richardson	W_2 NW NE 31	2 N	15 E	3,542	Pleistocene	Viola	Rich-Co. Oil Co.			Dry and abandoned
26	Richardson	NE SW 5	1 N	16 E	2,181	Pleistocene	Mississippian	H. S. Campbell et al.			Dry and abandoned
27	Richardson	W_2 SE SE 17	1 N	16 E	2,320	Alluvium on U. Penn.	Hunton	Towle et al.	50	[b]	50 bbl. oil + 75 per cent water
28	Richardson	C SW NE 16	3 N	16 E	2,705	Pleistocene	Hunton	Cities Service Oil Co.			Dry and abandoned
29	Richardson	W_2 SW SW 25	3 N	16 E	2,530	Pleistocene	Hunton	Skelly Oil Co.	120 = 22 hr.	[c]	Natural
30	Richardson	SE SE 26	3 N	16 E	2,534	Pleistocene	Hunton	J. E. Palensky et al.			Testing
31	Richardson	E_2 NE SW 26	3 N	16 E	2,640	Pleistocene	Hunton	O.C. Johnson et al.			Dry and abandoned
32	Richardson	C NW SW 34	3 N	16 E	2,606	Pleistocene	Hunton	Davisson et al.			Dry and abandoned
33	Richardson	E_2 NE NE 35	3 N	16 E	2,505	Pleistocene	Hunton	Skelly Oil Co.	181 = 16 hr.	[c]	8 per cent water
34	Richardson	E_2 SE NE 35	3 N	16 E	2,488	Pleistocene	Hunton	Skelly Oil Co.	100+	[c]	No potential test
35	Richardson	C NW SW 36	3 N	16 E	2,468	Pleistocene	Hunton	Skelly Oil Co.	100 (10 hr.)	[c]	
36	Richardson	W_2 SW NE 36	3 N	16 E	2,438	Pleistocene	Hunton	Skelly Oil Co.	100+	[c]	
37	Richardson	W_2 NW SE 36	3 N	16 E	2,438	Pleistocene	Hunton	Skelly Oil Co.	100 (11 hr.)	[c]	4 per cent water cut
38	Richardson	C NE NW 36	3 N	16 E	2,459	Pleistocene	Hunton	Skelly Oil Co.	100+	[c]	Producer
39	Richardson	W_2 SW SE 36	3 N	16 E	2,427	Pleistocene	Hunton	Taylor-Jarvis	37	[c]	37 bbl. oil + 36 bbl. water per 24 hr.

40	Richardson................	W_2 SE SW 36	3 N	16 E	2,508	Pleistocene	Hunton	Skelly Oil Co.	300	[a]	16 per cent water, 4 per cent B.S.
41	Richardson................	C NE NW 24	1 N	17 E	2,531	Pleistocene	Hunton	Ferguson and Towle			Dry and abandoned
42	Richardson................	W_2 NW NW 6	2 N	17 E	2,491	Pleistocene	Hunton	Nebr. Prod. and Ref. Co.			Dry and abandoned
43	Sarpy....................	NW NW NW 3	12 N	11 E	1,323	Pleistocene	Pre-Cambrian	Allen & Sherritt			Dry and abandoned
44	Sarpy....................	S_2 SW SE 15	13 N	12 E	1,300±	Pleistocene	Pre-Cambrian	Hough et al.			Dry and abandoned
45	Scottsbluff...............	NW SW 6	20 N	54 W	Drilling	Tertiary (Brule)		Fuerst Prod. Co.			Drilling
46	Sherman..................	NW NW 21	13 N	13 W	3,403	Tertiary (Brule)	Arbuckle	Carter Oil Co. & Pioneer Expl. Co.			Dry and abandoned

[a] Producer Dawson field. [b] Producer Falls City field. [c] Producer Barada field.

this horizon in the state. It is hoped that is may be possible in the future to eliminate some of the water trouble in the Viola with more refined completion methods.

Most of the drilling was confined to Richardson County, where there were 26 completions, including all of the producers. Three tests were completed in Gage County, two each in Adams, Lincoln, Nemaha and Sarpy Counties. The rest of the drilling was scattered over the state in nine different counties.

The Harlan County wells, which had showed some oil in the Kansas City-Lansing during the latter part of 1941, failed to develop commercial production and a third well completed in the vicinity in 1942 gave similar results, although there was some encouragement to hope for the future. To date it has been impossible to shut off the water in formations contiguous to the possible producing zones. A test well in sec. 16, T. 9 N., R. 33 W. found a show of oil in a sandstone in the Cherokee but testing failed to yield oil in commercial amounts.

Oil production from the four fields of Richardson County dropped from almost 1,887,000 bbl. in 1941 to slightly more than 1,276,000 bbl. in 1942, although the number of producing wells increased from 70 to 86. Production in the Falls City field dropped to about 50 per cent of the 1941 figure, and there was a marked increase in production in the Barada field. The Shubert field produced only about one third as much oil in 1942 as in 1941, while the Dawson field showed an increase of approximately 10,000 barrels.

Oil and Gas Development in New Mexico in 1942

By John M. Kelly,* Member A.I.M.E.

New Mexico produced 31,913,816 bbl. of oil in 1942, the lowest annual production since 1936, and dropped one place to rank eighth among oil-producing states. This production decreased 7,838,052 bbl., or 19.71 per cent, from the 1941 figure is the result of transportation difficulties caused by the dislocation of tanker sailings to east coast ports.

The average per-well allowable in New Mexico on Jan. 1, 1942, was 43 bbl. and at the end of the year was 38 bbl. Allocations as set by the New Mexico Oil Conservation Commission followed the recommendations of the Petroleum Administrator for War. After setting the daily outlet, however, the average daily pipe-line runs were 87,545 bbl.—11.06 per cent short of these allocations. Production for Lea County was 26,812,949 bbl., Eddy County 4,624,578 bbl., northwestern New Mexico 473,609 bbl., Chaves County 2,680 barrels.

Drilling activity for New Mexico in 1942 was approximately 84 per cent of that in 1941 with 339 completions. Of these completions 254 were oil wells, 11 gas wells, and 74 dry holes. Proven fields accounted for 55 of the dry holes and 19 were wildcats.

Three new oil fields and one new gas field were discovered as the result of wildcat drilling. Extensions were made to one oil field and one gas field. By the close of the year, the New Mexico Oil Conservation Commission had designated 59 areas as proven for oil and/or gas.

Southeastern New Mexico

Lea County

Monument was again the largest producing field in the state, with 5,729,336 bbl.; Eunice was next, with 5,217,965; Vacuum produced 3,295,624 and Hobbs 2,973,488.

The Hobbs field has the largest accumulated production, which at the close of 1942 totaled 100,381,417 bbl. The 100-million-barrel mark for Hobbs focused attention on the fact that this is the first field in the state to attain this figure, and also that, as Hobbs has been under continuous proration since July 1930, or approximately the entire life of the field, this 100-million-barrel recovery was obtained with 86 per cent of the wells in the pool still flowing and having a drop in bottom-hole pressure of only 3.5 lb. per million barrels recovered. Hobbs stands out as perhaps the best regulated major oil field in the world.

Two new oil fields were discovered in Lea County, the most important being the area designated as East Lusk, consisting of the south 4 tiers of Sections in T. 19 S., R. 32 E. The discovery well was drilled in the SW. SW. ¼ of sec. 21, T. 19 S., R. 32 E., by Culbertson and Irwin, Inc., and others. It was completed at a total depth of 2751 ft. in the Seven Rivers formation of Permian age. The initial potential of the well was 237 bbl. per day on pump. The oil produced has a gravity of 24.10 A.P.I., with sulphur content of 0.9 per cent. This oil has an asphaltic base and because

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TABLE 1.—*Oil and Gas Production in New Mexico*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
1	Anderson, *Eddy*	1940	1,280	0	440,051	156,455
2	Arrowhead, *Lea*	1938	4,440	3,320	4,213,857	1,199,702
3	Artesia, *Eddy*	1923	5,250	160	4,805,912	198,878
4	Aztec-Bloomfield, *San Juan*	1924	90	80	41,391	681
5	Barber, *Eddy*	1936	800	40	368,769	213,394
6	Barker Creek, *San Juan*	1942	0	480	0	0
7	Blanco, *San Juan*	1929	40	40	1,424*y*	28
8	Caprock, *Lea*	1940	40	0	1,930	384
9	Comanche, *Chaves*	1936	120	0	10,870*y*	2,680
10	Cooper, *Lea*	1929	4,320	360	13,876,514	782,741
11	Corbin, *Lea*	1938	80	40	35,119	8,495
12	Dayton, *Eddy*	1940	400	40	57,026	18,137
13	East Lusk, *Lea*	1942	240	0	24,108	24,108
14	East Maljamar, *Lea*	1942	80	0	5,434	5,434
15	Eaves, *Lea*	1929	880	160	1,835,226	227,675
16	Eunice, *Lea*	1928	20,080	19,360	58,816,200	5,217,965
17	Fulcher Basin, *San Juan*	1934	0	580	0	0
18	Getty, *Eddy*	1928	240	0	697,992	93,885
19	Grayburg-Jackson, *Eddy*	1936	7,960	160	11,600,087	1,509,527
20	Halfway, *Lea*	1939	400	0	251,357	73,369
21	Hardy, *Lea*	1935	4,960	920	4,509,162	531,812
22	High Lonesome, *Eddy*	1939	280	120	22,238	5,707
23	Hobbs, *Lea*	1928	10,240	9,960	100,381,417	2,973,488
24	Hogback, *San Juan*	1922	160	0	2,161,695	63,713
25	Hospah, *McKinley*	1927	580	0	681,797	297,082
26	Jal, *Lea*	1927	1,400	520	6,336,181	106,261
27	Kutz Canyon, *San Juan*	1927	0	2,520	0	0
28	Langlie, *Lea*	1927	5,360	1,520	7,710,431	972,269
29	Leo, *Eddy*	1939	280	0	75,212	20,703
30	Leonard, *Eddy*	1929	1,120	400	1,013,396	118,716
31	Loco Hills, *Eddy*	1939	8,040	80	6,535,496	1,593,964
32	Lynch, *Lea*	1929	440	0	6,134,430*y*	92,475
33	Lynn, *Lea*	1929	1,520	360	1,585,052	260,508
34	Maljamar, *Lea*	1926	7,280	40	5,459,841	1,664,082
35	Mattix, *Lea*	1936	7,680	680	7,019,860	934,643
36	McMillan, *Eddy*	1938	80	0	484	95
37	Monument, *Lea*	1934	20,200	16,800	51,540,498	5,729,336
38	North Lynch, *Lea*	1929	80	0	1,038,713	7,647
39	North Maljamar, *Lea*	1939	40	0	2,917	245
40	Penrose, *Lea*	1935	7,660	5,800	7,737,059	805,719
41	Rattlesnake, *San Juan*	1924	640	0	4,599,303	76,729
42	Red Lakes, *Eddy*	1924	2,840	680	607,383	104,695
43	Red Mountain, *McKinley*	1933	20	0	6,260*y*	860*y*
44	Rhodes, *Lea*	1928	1,320	1,040	518,714	121,213
45	Robinson, *Eddy*	1926	520	40	425,897	38,241
46	Russell, *Eddy*	Gas 1941 Oil 1942	160	40	4,835	4,835
47	Salt Lake, *Lea*	1941	320	0	68,931	54,901
48	Shugart, *Eddy*	1938	1,440	0	664,641	185,769
49	Skaggs, *Lea*	1936	120	0	96,088	20,757
50	Skelly, *Lea*	1936	3,600	3,040	3,067,047	380,554
51	South Eunice, *Lea*	1930	3,920	200	5,500,683	666,512
52	South Lovington, *Lea*	1938	4,080	200	1,632,579	451,638
53	South Maljamar, *Lea*	1939	240	0	77,732	46,516
54	Square Lake, *Eddy*	1941	3,800	40	356,376	347,913
55	Table Mesa, *San Juan*	1925	100	0	608,774	34,516
56	Ute Dome, *San Juan*	1921	0	640	0	0
57	Vacuum, *Lea*	1929	14,120	13,760	16,575,520	3,295,624
58	West Eunice, *Lea*	1928	760	0	474,767	156,876
59	West Lusk, *Eddy*	1941	80	0	13,664	13,664
60	Total		162,200	84,220	342,328,340*y*	31,913,816*y*

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[b] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operations[d]
				During 1942		End of 1942			Number of Wells				
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942	
1	264	94	32	3	1	0	31	0	27	4	*x*	*x*	0
2	4,824	2,200	111	8	0	0	111	0	111	0	1,460	1,356	0
3	16,609	60	211*y*	10	0	3	172	3	4	168	*y*	*y*	0
4	82*y*	82	34	0		8	13	2	0	13	*y*	*y*	0
5	*x*	*x*	21	4	1	0	19	1	0	19	550*y*	450*y*	0
6	932	932	3	3	0	0	0	3			*x*	*x*	0
7	340	35	1	0	0	0	1	1	1	0	1,200	950	0
8	*x*	*x*	1	0	0	0	1	0	0	1	*x*	*x*	0
9	*x*	*x*	3	0	0	0	3	0	0	3	*x*	*x*	0
10	111,840	5,232	114	4	2	0	89	6	36	53	1,398	*x*	0
11	*x*	*x*	3	0	0	1	2	0	1	1	1,398	*x*	0
12	27	9	11	0	0	3	8	0	8	0	*x*	*x*	0
13	*x*	*x*	6	6	0	0	6	0	0	6	*x*	*x*	0
14	*x*	*x*	2	2	0	0	2	0	1	1	*x*	*x*	0
15	9,715	1,567	26	0	0	0	23	2	9	14	*x*	*x*	0
16	237,950	21,744	505	0	4	0	484	3	416	68	1,400	992	0
17	1,383	748	7	1	0	0	0	7			576	576	0
18	*x*	*x*	9	0	0	4	5	0	0	5	0	0	0
19	17,155	2,284	211	29	0	0	197	2	155	42	*x*	*x*	0
20	*x*	*x*	10	0	0	0	9	0	0	9	*x*	*x*	0
21	255,068	2,283	129	0	1	0	122	0	93	29	1,400	*x*	0
22	312	22	10	0	0	2	5	3	0	5	*x*	*x*	0
23	209,307	4,318	270	2	0	1	253	3	214	39	1,550	1,180	0
24	*x*	*x*	7	0	0	0	7	0	7	0	560	560	0
25	*x*	*x*	29	9	0	0	29	0	0	29	*x*	*x*	0
26	41,105	3,825	48	0	1	0	19	8	8	11	*x*	*x*	0
27	14,328	1,370	17	0	0	0	0	17			565	400	0
28	83,290	21,106	150	0	0	0	121	20	108	13	1,450	*x*	RP
29	28	8	7	1	0	0	7	0	2	5	*x*	*x*	0
30	1,439	62	38	6	0	0	25	8	16	9	*x*	*x*	0
31	8,711	1,247	201	9	0	4	189	0	159	30	950	532	PM
32	*x*	*x*	16	0	0	1	10	0	0	10	*x*	*x*	0
33	12,090	4,553	43	2	0	0	30	5	15	15	1,365	*x*	0
34	17,976	1,432	190	32	0	1	173	0	157	16	*x*	*x*	RP
35	44,405	12,010	180	2	0	0	155	8	131	24	1,400	*x*	0
36	*x*	*x*	2	0	0	0	1	0	0	1	*x*	*x*	0
37	139,444	13,413	513	5	0	5	494	0	477	17	1,427	1,265	0
38	39	3	2	0	0	0	2	0	0	2	*x*	*x*	0
39	*x*	*x*	1	0	0	1	0	0	0	1	*x*	*x*	0
40	41,120	6,456	194	1	0	0	191	0	154	37	*x*	*x*	0
41	*x*	*x*	78	0	8	0	35	0	0	35	*x*	*x*	0
42	731	45	86	5	3	0	59	16	0	59	*x*	*x*	0
43	*x*	*x*	7	0	0	0	6	0	0	6	*x*	*x*	0
44	51,244	9,790	39	4	0	0	17	10	16	1	1,397	*x*	0
45	171	15	14	0	0	0	12	0	2	10	*x*	*x*	0
46	*x*	*x*	5	4	0	1	4	0	0	4	*x*	*x*	0
47	*x*	*x*	8	3	0	0	8	0	0	8	*x*	*x*	0
48	305	111	36	4	0	0	33	0	21	12	*x*	*x*	0
49	285	57	3	0	0	0	3	0	2	1	*x*	*x*	0
50	13,709	2,926	100	3	0	0	83	4	44	39	1,420	*x*	0
51	20,787	3,186	101	2	0	0	77	3	72	5	1,455	1,170	0
52	1,260	325	44	1	0	0	41	1	31	10	1,670	1,156	0
53	13	10	6	0	0	0	5	0	4	1	*x*	*x*	0
54	216	212	96	91	0	1	95	0	94	1	950	860	0
55	*x*	*x*	6	0	0	0	6	0	0	6	*x*	*x*	0
56	8,102	723	3	0	0	0	0	3			720	520	0
57	13,725	2,878	384	3	0	0	344	0	240	104	1,630	1,295	0
58	7	5	19	4	0	0	19	0	7	12	1,300	*x*	0
59	*x*	*x*	2	1	0	0	2	0	0	2	*x*	*x*	0
60	1,380,338*y*	127,378*y*	4,405*y*	261	21	36	3,858	139	2,843	1,016			

TABLE 1.—(*Continued*)

Line Number	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
							Depth, Avg. Ft.					
	Gravity A.P.I. at 60°F. Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	36.0	0.9	Grayburg	Per	S	*x*	2,527	2,638	*x*	A	San Andres Per	3,634
2	36.0	1.0	Grayburg	Per	D	Cav	3,720 460	3,800 495	80	A	San Andres Per	3,960
3	35.0	1.039	Grayburg	Per	LS	*x*	1,875	2,000	*x*	AM	San Andres Per	4,035
4	55.0	0.1	Farmington sand	CreU	S	*x*	750	1,075	25	S	Lewis Shale CreU	2,665
5	20.5	0.9	Yates	Per	L	Cav	1,480	1,570	*x*	A	Capitan Per	1,953
6			Dakota sand	CreU	S	*x*	2,350	2,400	50	D	McElmo CreL	3,285
7	54.0	0.13	Mesa Verde, Pictured Cliffs	CreU	S	*x*	4,250	4,550	5	H	Mesa Verde CreU	4,550
8	36.0	1.0	Seven Rivers	Per	S	*x*	3,025	3,052	27	A	San Andres Per	3,052 4,085 P.B.
9	28.5	0.9	San Andres	Per	L	*x*	*x*	1,283	*x*	ML	Capitan Per	1,400
10	29.9	1.50	Seven Rivers	Per	D	Cav	3,542	3,609	55	A	Lower San Andres Per	5,095
11	30.5	1.0	Queen	Per	D	Cav	4,258	4,322	45	A	San Andres Per	4,139 5,118 P.B.
12	20.5	0.10	San Andres	Per	LS	Fis	1,096	1,166	50	A	San Andres Per	2,545
13	24.10	0.9	Seven Rivers	Per	L	*x*	2,702	2,761	25	A	Seven Rivers Per	2,820
14			Grayburg and San Andres	Per	L	*x*	4,375	4,454	42	A	San Andres Per	4,805
15	28.5	1.0	Yates and Seven Rivers	Per	S	*x*	3,170	3,260	*x*	A	San Andres Per	3,542
16	33.8	1.28	Grayburg	Per	D	Cav	3,800	3,882	75*y*	A	San Andres Per	4,404
17			Pictured Cliffs	CreU	S	*x*	1,800	1,960	160	H	Pictured Cliffs CreU	1,989
18	24.0	0.9	Yates	Per	LS	*x*	1,365	1,380	15	A	Permian	6,683
19	35.5	0.94	San Andres	Per	LS	*x*	3,598	3,655	45	A	San Andres Per	4,383
20	28.6	0.9	Yates	Per	LS	*x*	2,590	2,630	25	A	San Andres Per	4,005
21	35.0	0.9	Grayburg	Per	D	Cav	3,710	3,763	53	A	San Andres Per	3,872
22	34.9	1.56	Grayburg	Per	LS	*x*	2,610	2,676	40	A	San Andres Per	3,163
23	34.5	1.0	San Andres	Per	D	Cav	4,050	4,074	123	A	San Andres Per	4,500
24	60.0	0.1	Dakota sand	CreU	S	*x*	705	714	9	D	McElmo CreL	1,225
25	29.0	0.15	Hospah sand	CreU	S	*x*	1,639	1,650	11	DF	Dakota CreU	3,282
26	36.0	1.0	Seven Rivers	Per	D	Cav	3,303	3,334	31	A	San Andres Per	4,125
27			Pictured Cliffs	CreU	S	*x*	1,840	1,900	60	H	Mesa Verde CreU	4,400
28	38.0	0.9	Seven Rivers	Per	S	*x*	3,350	3,530	*x*	A	Montoya OrdU	8,079
29	35.8	0.94	Grayburg	Per	S	*x*	3,170	3,275	*x*	ML	San Andres Per	3,857
30	36.0	0.90	Grayburg and San Andres	Per	S	*x*	2,760	2,816	*x*	A	San Andres Per	3,591
31	36.5	0.90	Grayburg	Per	S	*x*	2,615	2,809	80*y*	A	San Andres Per	3,453
32	30.0	1.0	Yates and Seven Rivers	Per	D	Cav	3,760	3,777	17	A	San Andres Per	4,046
33	29.0	1.0	Seven Rivers .	Per	D	Cav	3,550	3,776	*x*	A	San Andres Per	5,095
34	36.0	0.9	San Andres	Per	L	*x*	3,960	4,050	*x*	A	Lower San Andres Per	5,150
35	37.3	1.0	Yates and Seven Rivers	Per	S	*x*	3,500	3,554	45	A	San Andres Per	4,200
36	29.0	1.0	Queen	Per	S	*x*	1,200	1,414	*x*	A	San Andres Per	3,305
37	34.1	1.20	Grayburg and San Andr[illegible]	Per	D	Cav	3,829	3,938	89	A	San Andres Per	4,534
38	30.0	1.0	Yates and Seven Rivers	Per	D	Cav	3,760	3,777	17	A	San Andres Per	4,046
39	33.0	1.0	Grayburg	Per	D	*x*	3,875	4,015	75	A	San Andres Per	4,097
40	35.2	1.0	Grayburg	Per	S	*x*	3,550	3,668	90	A	San Andres Per	4,705
41	64.5	0.20	Dakota sand	CreU	S	*x*	3,550 465	3,668 498	90	A	Ignacio Quartzite CamU	7,397
42	36.2	0.9	Grayburg	Per	S	*x*	1,904	1,930	*x*	A	San Andres Per	2,905
43	42.0	0.1	Mesa Verde	CreU	S	*x*	438	457	13	AF	Mesa Verde CreU	640
44	35.0	1.0	Seven Rivers	Per	S	*x*	3,050	3,286	*x*	A	San Andres Per	4,115
45	34.5	0.9	Grayburg	Per	S	*x*	3,919	4,009	80	A	San Andres Per	4,359
46	38.0	0.8	Yates	Per	S	*x*	799	885	*x*	A	San Andres Per	2,500
47	26.0	0.9	Yates and Seven Rivers	Per	LS	*x*	3,018	3,066	48	A	San Andres Per	3,825
48	33.0	0.9	Yates and Queen	Per	S	*x*	3,450	3,680	*x*	A	San Andres Per	4,890
49	36.0	1.0	Grayburg	Per	L	*x*	3,800	3,860	60	A	San Andres Per	4,757
50	37.4	1.0	Grayburg	Per	S	*x*	3,525	3,663	*x*	A	San Andres Per	4,052
51	33.0	1.0	Seven Rivers	Per	D	Cav	3,775	3,845	70	A	San Andres Per	6,202
52	33.0	1.0	San Andres	Per	L	*x*	4,350	5,094	*x*	A	San Andres Per	5,501
53	33.5	1.0	Yates	Per	L	*x*	3,818	3,880	62	A	San Andres Per	4,500
54	37.8	0.8	Grayburg	Per	S	*x*	2,996	3,057	17	A	San Andres Per	4,058
55	57.0	0.03	Dakota sand	CreU	S	*x*	1,325	1,337	12	A	Chinle TriU	3,010
56			Dakota sand	CreU	S	*x*	2,285	2,350	60	D	Dakota Sand CreU	2,590
57	35.5	1.0	San Andres	Per	D	Cav	4,316	4,703	*x*	A	San Andres Per	5,329
58	31.0	1.0	Seven Rivers	Per	L	*x*	3,773	3,824	51	A	San Andres Per	4,695
59	26.0	0.9	Seven Rivers	Per	L	*x*	2,509	2,641	20*y*	A	Seven Rivers Per	2,763
60												

of the war demand for this type of oil for airport paving, wells in this area, and other areas where similar oil is produced, were given a special allowable of 100 bbl. per day. Outlet for this area is by truck to the New Mexico Asphalt and Refining Co. at Artesia, New Mexico.

The second oil-field discovery in Lea County, consisting of all of T. 17 S., R. 33 E., was called East Maljamar. The discovery well was the Phillips Petroleum Company's Phil-Mex. No. 1, in NW. NW. ¼ sec. 28, T. 17 S. R. 33 E., at a total depth of 4771 ft. in San Andres Permian, and plugged back to 4601. Initial production was 25 bbl. per day on the pump. At the end of the year two oil wells and two dry holes had been completed in the area. One of the oil wells was producing and one, the discovery well, was shut in.

The greatest drilling activity in Lea County for the second consecutive year was in the Maljamar area of the county, with 35 completions, consisting of 31 oil wells, 1 gas well, and 3 dry holes. One of the dry holes was the deepest test to date for this area, being abandoned at a total depth of 5150 ft. in the lower San Andres limestone of Permian age.

On Aug. 5, 1942, the majority of the operators in the Maljamar area entered into a Cooperative Repressuring Agreement and at the end of the year 125 wells were affected and operations were apparently progressing satisfactorily.

The deepest test to date in New Mexico was still drilling at the close of the year and had reached a total depth of 8079 ft. in the Montoya formation of Ordovician age. This well, Olsen et al. Langlie No. 1, SE. SE. ¼ sec. 11, T. 25 S., R. 37 E., is to be drilled to the Ellenburger formation of lower Ordovician, which is expected to be productive at approximately 9500 feet.

Eddy County

The Loco Hills field continued to be the leading producing area in Eddy County, with 1,593,964 bbl., closely followed by Grayburg-Jackson with 1,509,527 bbl. Grayburg-Jackson led the county in total recovery to date, with 11,618,884 barrels.

One new oil field was discovered in Eddy County. The discovery well was drilled by Neil H. Wills in the NW. SW. ¼ sec. 13, T. 20 S., R. 28 E., and completed at a total depth of 906 ft. in the Yates sand of Permian age. The discovery well pumped and flowed 27 bbl. per day. This area, designated as the Russell area, embraces all of T. 20 S., R. 28 E. The area was proven for gas in 1941 but to date no gas sales have been made. At the end of the year there were four producing oil wells and one shut-in gas well in this area.

The most active drilling campaign in New Mexico for 1942 was the Square Lake area of Eddy County. Completions totaled 93, of which 91 were oil wells and 2 dry holes.

The boundaries of this area, as ordered by the Oil Conservation Commission for proration purposes, embrace all of T. 16 S., R. 30 E., the western half of T. 16 S., R. 31 E.; secs. 1, 2, 3, 4 and 5, T. 17 S., R. 30 E. and secs. 4, 5 and 6, T. 17 S., R. 31 E.

Discovery for this area was made by Sanders Brothers et al., Leonard No. 1 in SE. SW. ¼ sec. 34, T. 16 S., R. 30 E., completed Nov. 9, 1941, and reported as an extension to the then existing proration area of High Lonesome. This well was completed at a total depth of 2982 ft. in the lower Grayburg formation of Permian age. Initial production was reported as 77 bbl. per day with 59 M cu. ft. gas flowing through open 2-in. tubing.

Drilling in this area is all done by cable tools, and in most wells salt water is encountered in the "Artesia red sand," at the top of the Queen formation, which necessitates the running of an extra string of casing, almost all of which is recoverable.

To date the limits of the pool have been defined in only one direction, to the southwest. At the end of the year there were 95 producing oil wells and one shut-in gas well in the field. Production to the end of 1942 amounted to 356,376 bbl., of which 347,913 bbl. was produced in 1942.

The one extension to an oil field for the year was made by Sanders and Carper with their Vandagriff No. 1, in SW. NE. ¼ sec. 6, T. 19 S., R. 31 E., which extended the Shugart area 3 miles to the southwest. This well was completed at a total depth of 3573 ft. in Grayburg formation of Permian age for a potential of 42 bbl. per day on the pump.

NORTHWESTERN NEW MEXICO

Hospah field, McKinley County, again accounted for most of the oil production in northwestern New Mexico, with 297,082 bbl. for the year. Rattlesnake was the leading field in San Juan County, with 76,729 barrels.

Hospah also led in drilling activity, with 10 completions, 9 of which were oil wells and one was a dry hole. At the end of the year there were 29 producing oil wells in the field, all pumping, and the field apparently was defined in all directions except to the northeast.

The new gas field of New Mexico, named Barker Creek Dome, was discovered by Southern Union Production Co., with its Ute Reservation No. 1, NW. NW. ¼ of sec. 21, T. 32 N., R. 14 W., San Juan County. This well was drilled to a total depth of 2499 ft. and completed for a potential of 15 million cu. ft. of gas per day from the Dakota sand formation of the Upper Cretaceous. At the end of the year, three wells in the area were producing gas. The total produced by the area in 1942 was 932 million cu. feet.

TABLE 2.—*Summary of Drilling Operations in New Mexico*

Important Wildcats Drilled in 1942

	County	Location			Total Depth, Ft.	Surface Formation
		Sec.	Tp.	Rge.		
1	Chaves	15	14 S	29 E	3,318	Tertiary
2	Chaves	26	14 S	29 E	4,200	Tertiary
3	De Baca	5	4 N	20 E	4,779	Tertiary
4	Eddy	14	16 S	28 E	2,640	Jurassic
5	Eddy	15	16 S	30 E	3,802	Tertiary
6	Eddy	7	16 S	31 E	3,962	Tertiary
7	Eddy	20	18 S	31 E	4,035	Tertiary
8	Eddy	32	19 S	27 E	1,250	Permian
9	Eddy	11	19 S	30 E	2,270	Tertiary
10	Eddy	23	19 S	30 E	2,077	Tertiary
11	Eddy	6	19 S	31 E	3,573	Tertiary
12	Eddy	21	19 S	31 E	2,429	Tertiary
13	Eddy	13	20 S	28 E	906	Tertiary
14	Eddy	17	20 S	30 E	1,756	Permian
15	Eddy	16	21 S	23 E	2,887	Permian
16	Eddy	16	21 S	26 E	1,250	Permian
17	Lea	36	9 S	37 E	5,658	Tertiary
18	Lea	18	12 S	35 E	5,175	Tertiary
19	Lea	26	15 S	34 E	6,308	Tertiary
20	Lea	22	16 S	36 E	5,501	Tertiary
21	Lea	5	16 S	38 E	5,508	Tertiary
22	Lea	34	17 S	32 E	5,150	Tertiary
23	Lea	10	17 S	33 E	4,805	Tertiary
24	Lea	28	17 S	33 E	4,771	Tertiary
25	Lea	21	19 S	32 E	2,751	Tertiary
26	Lea	1	21 S	32 E	3,496	Tertiary
27	Lea	5	21 S	33 E	3,717	Tertiary
28	Lea	12	22 S	37 E	3,941	Tertiary
29	Lea	11	25 S	35 E	5,158	Tertiary
30	Otero	20	25 S	7 E	3,941	Tertiary
31	San Juan	21	32 N	14 W	2,499	Cretaceous
32	San Juan	13	29 N	19 W	6,950	Cretaceous

An extension to the Rattlesnake area was made by Continental Oil Co. with a test called Navajo No. 1, in NE. NE. SW. of sec. 13, T. 29 N., R. 19 W. This well was completed as a gas well at total depth of 6950 ft. in Ouray formation of Devonian age. Upon completion, operation was assumed by the U.S.A., with no completion gauge announced. No analysis of the gas is available, but it is unofficially reported to contain an appreciable amount of helium.

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TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1942

	Deepest Horizon Tested	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.		Remarks
			Oil, U. S. Bbl.	Gas, Millions Cu. Ft.		Casing	Tubing	
1	Whitehorse Permian	Brewer Drill. Co. et al.						Dry hole
2	San Andres Permian	Harry Steinberger						Dry hole
3	Pre-Cambrian schist	South Basin Oil Co.						Dry hole
4	Whitehorse Permian	Call and Brown		Good show				Abandoned
5	San Andres Permian	Premier Petr. Corp.						Dry hole
6	San Andres Permian	Archer and Jones	Good show oil and gas					Abandoned
7	San Andres Permian	Sunset Oil Co.						Dry hole
8	Grayburg Permian	Baker and Helms						Dry hole
9	Seven Rivers Permian	Culbertson & Irwin						Dry hole
10	Seven Rivers Permian	Culbertson & Irwin						Dry hole
11	Queen Permian	Sanders & Carper	42		Pump			Extension Shugart area
12	Seven Rivers Permian	Yates & Stroup						Dry hole
13	Yates Sand Permian	Neil H. Wills	27		Pump			Discovery Russell area
14	Capitan Permian	Keyes & Atwood						Dry hole
15	Yeso Permian	Stroup, Yates & Flynn						Dry hole
16	San Andres Permian	E. Orcutt et al.						Dry hole
17	Yeso Permian	Ohio Oil Co.	Good show	0.05				Abandoned
18	San Andres Permian	Mascho Oil Co.						Dry hole
19	Abo Permian	George P. Livermore						Dry hole
20	San Andres Permian	N. G. Penrose, Inc.						Dry hole
21	San Andres Permian	Richmond Drill Co.						Dry hole
22	Lower San Andres Permian	Southern Union Prod.						Dry hole
23	San Andres Permian	Richmond Drill Co.						Dry hole
24	San Andres Permian	Phillips Petr. Co.	25		Pump			Discovery East Maljamar
25	Seven Rivers Permian	Culbertson & Irwin	237		Pump			Discovery East Lusk
26	San Andres Permian	Culbertson & Irwin						Dry hole
27	San Andres Permian	Felmont Corporation						Dry hole
28	San Andres Permian	N. G. Penrose, Inc.						Dry hole
29	Delaware Sand Permian	Prexy Wilson et al.						Dry hole
30	Pennsylvanian	R. H. Ernest et al.						Dry hole
31	McElmo Cret.	Southern Union Prod.		15		675		Discovery Barker Creek
32	Ouray Lime Dev.	Continental Oil Co.		?		2,960		Extension Rattlesnake area

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	36	11
Number of oil wells completed during 1942	251	3
Number of gas wells completed during 1942	9	2
Number of dry holes completed during 1942	55	19

Petroleum and Natural Gas Developments in New York in 1942

By C. A. Hartnagel[*]

The production of petroleum in New York state in 1942 amounted to 5,410,000 bbl. This represents an increase over each of the four preceding years, and, with the exception of 1937, is the largest production since the peak of over six million barrels in 1882, shortly after the discovery of oil in Allegany County.

The oil industry in New York is virtually stabilized and there has been little or no exploration for new sources of supply in recent years. The boundaries of the present fields were established more than 30 years ago and since then no additional reserves have been found. Deep drilling for natural gas during the past 10 years both within and without the oil fields has failed to find oil in quantity below the present producing sands of Devonian age.

OIL

Since 1882, the New York fields have produced approximately 140 million barrels of oil. Of this amount, 65 million was produced up to the year 1919 by ordinary pumping methods; that is, without flooding by water or the use of other secondary-recovery methods. In the year 1919, when a law was passed making the use of water-flooding methods legal, the oil production of the state amounted to only 851,000 bbl. In the 23 years since 1919, there have been produced in the state 75 million barrels, or 10 million more than in the previous 37 years, which included the period of flush production.

Price.—On March 26, the price of crude oil was raised from $2.75 to $3.00 per barrel, but this increase had little or no effect on the number of wells drilled. In the Allegany field, which accounts for three fourths of the state's oil production, 1259 wells were completed in 1942, 7 less than in 1941. The smaller number of wells drilled was not only due to the shortage of labor but also was caused by the fact that in water-flooding territory a definite program for drilling wells is followed, and the flush period of an oil well is not usually reached in time to profit by any given price increase.

Daily Production.—All of the oil wells in New York state, some 21,000 in number, are small producers. The average daily oil production is $\frac{7}{10}$ bbl. per well. Under good flooding conditions, a maximum production of 5 to 8 bbl. a day is reached about one year after the flood begins to act on the well. In 5 years the daily production usually is less than one barrel.

Although most of the oil in New York is produced by flooding, an estimated 2500 old wells produce without flooding. Some of these produce as little as $\frac{1}{20}$ bbl. a day and are pumped only at intervals. The small producing wells are mostly on lands leased to the larger oil companies and later will be included in a flooding program. At present, they are pumped only because the owners of the land insist on the royalty.

Government Aid Needed.—Because of its good lubricating qualities, New York oil is one of those for which there is an insistent and growing demand, but even at its present price of $3.00 per barrel, many of the operators are producing at a loss.

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Increased prices of other commodities, high cost of labor, and an actual shortage of labor make it difficult to increase production. Moreover, the present high salvage value of well equipment is leading to the abandonment of some small producing wells, with the resultant loss of considerable oil that in all probability will never be recovered. It would seem that in circumstances such as these, the Federal or State government might well come to the aid of the small producer and make it possible to continue pumping valuable oil from these small wells.

TABLE 1.—*Wildcat Oriskany Tests in New York State in* 1942

County and Township	Name of Well	Elevation, Ft.	Depth to Oriskany Sand, Ft.	Drilled by	Initial Daily Production, M Cu. Ft.	Total Depth, Ft.	Remarks
Allegany County:							
1. Allen	Bessie Byron	1,976	3,326	H. French et al.		3,343	120 ft. salt water at 3332 ft. On completion 1000 ft. S. W. and no gas. Total depth in sandy lime
2. Andover	Mary E. Lynch	2,049	4,774	Belmont Q. D. Co.		4,776	450 ft. S. W. in 10 hr. No gas
3. Andover	Michael Lynch	2,068	4,804	Empire G. & F. Co.		4,808	At 4806 ft., hole filled 200 ft. S. W. in ½ hr. 3500 ft. in 24 hr.
4. Independence	Oscar A. Potter	2,197	4,942	Empire G. & F. Co.		4,952	Show of 28 M cu. ft. gas and S. W. at 4949 ft.
5. Independence	Hiram Miller	2,204	4,912	N. Y. S. Nat. Gas		4,916	14 M cu. ft. gas at 4913 ft. but S. W. at 4916. Hole filled to 1900 ft. in 5 days
6. Willing	John Ludden	2,236	5,001	Belmont Q. D. Co.		5,008	500 ft. of S. W. No gas
Steuben County:							
7. Fremont	Joel D. Russell	1,819	3,564	Empire G. & F. Co.	150	3,571	At 3567 ft. flow of 115 M cu. ft. before shot
8. Fremont	David P. Smith	1,840	3,580	Belmont Q. D. Co.	304	3,589	1400 lb. initial reservoir pressure. Top of Helderberg 3587 ft. 105 M cu. ft. before shot. First gas 5½ ft. in sand
9. Greenwood	Wm. Pease	2,212	4,840	N. Y. S. Nat. Gas		4,847	S. W. at 4844 ft.
10. Wayne	Frank Sleeve	1,585	2,411 2,421 bot.	Hanley & Bird		2,447	No water; no gas
11. W. Union	James B. Coleman	2,298	5,152	East. Roy. Inc.		5,156	S. W. at 5154 ft.
12. W. Union	Robert Lewis	2,265	5,213	E. Kent Kane	184.32	5,229	20 M cu. ft. at 5214 ft.; 60 M cu. ft. at 5220; 86 M cu. ft. at 5222; shot with 40 qt.; 5 gal. S. W. daily
13. W. Union	John Saxton No. 1	2,214	5,205	Penn-York		5,208	300 ft. S. W. in 2 hr.
14. W. Union	John Saxton No. 2	2,172	5,066	Penn-York		5,092	Show of 2 to 3 M cu. ft. gas and some S. W. at 5078 ft. 100 gal. S. W. in hole in 24 hr.
15. Woodhull	Parks Est. No. 4	1,550	3,966 3,989 bot.	N. Y. S. Nat. Gas	476	3,991	At 3968 ft. flow of 410 M cu. ft. of gas
Tompkins County:							
16. Danby	Andrew M. McCord	1,234	2,448	Belmont Q. D. Co.		2,488	No gas; no water
17. Danby	Mary Taubman	1,328	2,426	Fralich & Leiderbach		2,431	At 2430 ft., 1½ bailers S. W. every 2 hr.
18. Groton	Cora H. Mount	1,448	2,156	Belmont Q. D. Co.	1,800	2,167	300 M cu. ft. gas at 2158 ft. Gradually increased
19. Groton	Mary Ronan	1,334	2,052	Leiderbach et al.	650	2,062	650 M cu. ft. at 2059 ft.
20. Groton	Archie Gagnon	1,356	2,188	Belmont Q. D. Co.		2,192	3 bbl. S. W. per hr. at 2191 ft.
21. Groton	Frank Stoddard	1,391	2,156	N. Y. S. Nat. Gas		2,166	At 2164 ft. well filled 140 ft. with S. W. in 1 hr. Abandoned
22. Groton	Ray Teeter	1,337	2,080	Belmont Q. D. Co.		2,098	At 2083 to 2085 ft., ⅔ bailer S. W. per hr. No gas
23. Lansing	George Armstrong	979	1,598 1,609 bot.	Leiderbach et al.	200	1,619	Gas at 1601 ft.
24. Lansing	Josephine Crim	1,045	1,654	Belmont Q. D. Co.		1,657	Show 1270 M cu. ft. gas at 1655 ft. and 2 bbl. water per hour at 1656 ft.
25. Lansing	Ellen Townsend	413	1,028	Leiderbach et al.		1,038	Dry and abandoned
26. Lansing	Delta Nettles	902	1,536	Leiderbach et al.		1,543	No gas, but at 1539 ft. hole filled up 200 ft. with water in 1 hr.

Labeling Law.—After several unsuccessful attempts in previous years a law was finally enacted early in 1943 by the New York Legislature requiring the labeling of reclaimed oil. This statute is in line with fair practice procedure and is most welcome to New York producers, as well as to those in the neighboring state of Pennsylvania, where such a law is already in force.

NATURAL GAS

In 1942 drilling operations for natural gas in the Oriskany sand in the southern tier of counties failed to find any new pools, and initial production decreased for the fifth consecutive year. Almost all the wells drilled may be considered as wildcats, since no important operations were conducted in any of the proved gas areas.

In Allegany County six wells, five of them more than 4700 ft. deep, were completed but none proved to be producers. In Steuben County nine wells were drilled, of which four were small producers with a combined daily initial production of 1,114,000 cu. feet.

Attempts to find new supplies of gas from the Oriskany sandstone in Tompkins County met with only partial success. Of the 11 wells drilled one had an initial production of 1,800,000 cu. ft. Two others were listed as relatively small producers and eight were dry.

In the small Trenton limestone fields of Oswego and Oneida Counties, no new developments took place, whereas in the long developed Medina gas fields of western New York a few successful gas wells were added to the large number of previous producers.

Oil and Gas Development in Ohio in 1942

By Kenneth Cottingham,[*] Member A.I.M.E.

Many factors joined in reducing drilling activity in Ohio in 1942. Conservation Order M-68 was important, but other things, such as operators and members of drilling crews joining the armed services and going into war plants, had an important part.

The reduction in number of completions was considerable. In 1941, the total of wells drilled was 1561 but in 1942 the total was 1008. The total initial daily open flow discovered by the 701 gas wells drilled in 1941 was 492,000 M cu. ft., whereas the open flow of the 471 gas wells completed in 1942 was 314,488 M cu. ft. The total initial daily production of the 333 oil wells drilled in 1941 was 10,300 bbl., and in 1942 the 181 oil wells had a total daily initial of 7570 bbl. The average daily initial per gas well therefore was somewhat less in 1942 when compared with the preceding year, but the initial per oil well increased about 36 per cent over 1941.

General Activity

The total depth of the 652 oil and gas wells drilled in 1942 was 1,597,000 ft. The most active county was Perry, where 63 oil wells were drilled, most of them in Clayton township. In Morgan County, where 43 gas wells were drilled, the greatest activity was in York and Marion townships. Medina County was third in number of wells drilled, although of the total of 33 gas wells in the county, 26 were in the new Hinckley township pool. The total initial open flow of these 26 wells was 39,202 M cu. ft., and was considerably larger than from any other single area. Muskingum was an active county, particularly Washington and Wayne townships, in each of which seven gas wells were drilled, and Blue Rock and Harrison townships, in each of which five gas wells were drilled.

Table 1.—*Wells Drilled during 1942, in Ohio*

Sand	Oil Wells		Gas Wells		Number of Dry Holes	Total Number Drilled
	Number of Wells	Average Initial Daily per Well, Bbl.	Number of Wells	Average Initial Daily per Well, M Cu. Ft.		
Shallow	38	6	90	351	77	205
Berea	43	10	86	168	65	194
Ohio shale			7	131	6	13
Oriskany			10	1,682	3	13
Newburg			5	783	1	6
Clinton	88	77	273	904	188	549
Trenton	12	15			11	23
Sub-Trenton					5	5
Total	181	42	471	668	356	1,008

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Licking County, which was second in drilling activity in 1941, dropped to ninth place among the various counties in 1942, because the boundaries of the Newark pool, discovered in 1938, have not been extended. Noble County, in which a large number of shallow-sand and Berea wells usually are drilled, in 1942 had only 37 completions, 16 of which were dry, compared with 82 wells completed in 1941. The marked reduction may be partly due to the requirements of the spacing pattern adopted during the early part of the year. However, the average initial volumes of oil wells in this county is only 3 bbl. per day, and that of gas wells usually averages less than 100 M cu. ft. per day.

TABLE 2.—*Completions in Ohio in 1942, by Counties*

County	Oil Wells	Gas Wells	Dry Holes	Total
Ashland..........	2	19	20	41
Athens...........	8	19	23	50
Auglaize.........			1	1
Belmont..........		4	2	6
Carroll..........	2		2	4
Columbiana......	1	2	6	9
Coshocton........	4	9	12	25
Cuyahoga........		6	2	8
Fairfield.........		8	1	9
Fulton...........			1	1
Gallia...........		4	1	5
Greene..........			1	1
Guernsey........		9	4	13
Hancock.........	1			1
Harrison.........			1	1
Highland.........			1	1
Hocking.........	1	5	2	8
Holmes..........	1	16	15	32
Jackson..........		1		1
Jefferson.........	2		4	6
Knox............	2	19	31	52
Lawrence........		7	1	8
Licking..........	10	24	9	43
Lorain...........		15	15	30
Mahoning........	8			8
Medina..........	18	33	18	69
Meigs...........	2	42	22	66
Mercer..........	4			4
Monroe..........	7	18	11	36
Morgan..........	5	43	23	71
Muskingum......	8	33	14	55
Noble...........	4	17	16	37
Ottawa..........			2	2
Perry...........	63	21	26	110
Putnam.........	1			1
Richland........		3	1	4
Seneca..........			4	4
Stark...........		12	7	19
Summit..........		11	5	16
Trumbull........			1	1
Tuscarawas......		23	4	27
Vinton..........		1	7	8
Washington......	19	24	25	68
Wayne..........	2	23	8	33
Williams........			1	1
Wood...........	5		3	8
Wyandot.........	1		3	4
Totals.........	181	471	356	1,008

HORIZONS TESTED

More than half of the wells completed during 1942 were drilled to the Clinton sand. The Clinton tests were scattered over 23 counties, all of which have had Clinton production for many years. Perry County, with a total of 95 Clinton wells, was by far the most active. Of these, 58 were oil, 14 were gas wells, and 23 were dry.

TABLE 3.—*Production of Oil in Ohio in 1942, Tabulation by Grade*

Grade	Number of Wells	Barrels
Pennsylvania..............	11,448	1,751,566
Lima......................	7,847	357,672
Corning...................	3,596	972,346
Lodi......................	1,189	582,294
Total..................	24,080	3,663,978

Although there is still a great deal of speculation concerning the finding of new gas in the Oriskany sand, little was done in that direction in the past year. A small productive area was developed in the Oriskany in Liberty and Wheeling townships, Guernsey County, north of the old Cambridge field. Six wells, one of which was dry, were drilled in this field during 1942. The wells average about 3300 ft. in depth, and the daily initial open flow of the five producing wells averaged 1456 M cu. ft. per well.

In Cuyahoga County, four Oriskany gas wells were drilled in Mayfield township. This is an area in which deeper Newburg gas was discovered in 1938. The Oriskany here is about 1890 ft. deep, and the initial open flow of the four wells averaged about 2327 M cu. ft. per well.

An Oriskany well having an initial volume of 238 M cu. ft. was drilled in Richfield township, Summit County. In Meigsville township, Morgan County, a dry hole was drilled in an attempt to find Oriskany gas, and an Oriskany dry hole was also drilled in Adams township, Washington County.

Except for one well in Greene County and one in Highland, all Trenton drilling was in northwestern Ohio. In all, 23 Trenton tests were drilled, of which 12 were oil wells and 11 were dry.

TABLE 4.—*Data for Five Years in Ohio*

COMPLETIONS

Year	Number of Wells Drilled during Year			Total
	Oil	Gas	Dry	
1938	189	433	288	910
1939	170	501	349	1,020
1940	327	491	410	1,228
1941	333	701	527	1,561
1942	181	471	356	1,008
Total....	1,200	2,597	1,930	5,727

ANNUAL OIL PRODUCTION, BARRELS

Year	Production	Number of Oil Wells	Average per Well
1938	3,298,000	26,880	123
1939	3,156,000	25,680	123
1940	3,169,000	25,500	124
1941	3,510,000	24,801	142
1942	3,663,978[a]	24,080	152

NATURAL GAS, THOUSANDS CUBIC FEET

Year	Annual Production	Annual Consumption
1937	42,783,000	125,133,000
1938	35,257,000	108,013,000
1939	36,469,000	114,720,000
1940	40,639,000	129,856,000
1941	41,858,000[a]	136,251,000[a]

[a] Preliminary estimate.

Sub-Trenton tests numbered five. Three of these were in Wyandot County, the deepest being in Jackson township, finishing in the Green sand with a depth of 3475 ft. All five tests were dry. A St. Peter well was drilled in Perrysburg township, Wood County, and was dry at a depth of 2057 ft. In Scipio township, Seneca County, a dry hole was drilled to 3123 ft. in the Green sand.

LARGE WELLS DRILLED

The largest gas well of the year was drilled in sec. 26, York township, Morgan County. The initial open flow was 11,700 M cu. ft., the initial rock pressure 1030 lb. The producing formation is the Clinton, and the total depth 4261 ft. A Clinton well in sec. 17, Washington township, Holmes County, at a depth of 2989 ft., had initials of 9220 M cu. ft. and 1350 lb. In sec. 26, York township, Morgan County, a Clinton well 4341 ft. deep had an initial open flow of 6000 M cu. ft. and a rock pressure of 1020 lb. In southern Ohio, in sec. 19, Greenfield township, Gallia County, a well was completed in the Clinton, total depth 2988, the initial open flow of which was 5050 M cu. ft. and the rock pressure 1000 lb. In lot 29, Hinckley township, Medina County, a well 3491 ft. deep in the Clinton sand gauged 5000 M cu. ft. when completed.

TABLE 5.—*Prices of Crude Oil in Ohio during* 1942

Grade.........	Pennsylvania	Corning	Lima	Lodi
Dec. 31, 1941...	$2.30	$1.31	$1.17	$1.30
March 26, 1942	2.55			
Dec. 31, 1942...	2.55	1.31	1.17	1.30

The largest oil well of the year was the Clinton well in sec. 7, Newton township, Muskingum County, the depth of which was 3406 ft. and the initial yield 495 bbl. Clayton township, Perry County, where Clinton oil was discovered in 1936, and which in 1942 was the outstanding oil area in Ohio, had at least five wells that produced initially more than 200 bbl. each. The largest of these was in sec. 8, the initial production being 287 bbl. and the depth 3295 ft. In sec. 13, Thorn township, Perry County, the Clinton sand furnished a 220-bbl. well of which the depth was 2806 ft.

Other large oil wells were in lot 55, Hinckley township, Medina County, 160 bbl. from the Clinton at 3171 ft.; sec. 22, Pike township, Coshocton County, 100 bbl., Clinton, at 3143 ft.; and sec. 23, Hopewell township, Licking County, 100 bbl. from the Clinton at a depth of 3095. In the old Trenton field, a well larger than usual was drilled in sec. 1, Liberty township, Wood County. This was reported as being an 80-bbl. well having a total depth of 1349 ft. in the Trenton.

DEEP DRILLING

No unusually deep wells were drilled, the deepest of the year being a Clinton dry hole in Union township, Tuscarawas County, which ended at 5500 ft. The deepest gas well was in Fairfield township, Tuscarawas County, which had an initial volume in the Clinton of 898 M cu. ft. at 5313 ft. As this report is written, a deep test, probably to the Trenton, is drilling at 6850 ft. in Olive township, Meigs County. The Clinton sand in this test was found at 5398 ft., had a thickness of 18 ft. but contained neither oil nor gas.

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Oil and Gas Development in Oklahoma in 1942

By Raymond D. Sloan,* Member A.I.M.E.

Retaining third place in crude-oil production among the nation's oil-producing states, Oklahoma's output in 1942 totaled 137,792,000 bbl., a decline of 9.4 per cent from the previous year's total of 152,117,000 bbl. Production declined from an average of 403,000 bbl. daily in January 1942 to an average of 355,000 bbl. during December, a reduction of 48,000 bbl. daily (11.9 per cent) during the year. At the end of 1942 it would appear inevitable that the downward trend in production will continue in 1943 unless halted in the immediate future by greater than normal discoveries and development. To Jan. 1, 1943, Oklahoma has produced 5,067,013,000 bbl. of crude oil.

Development and Exploration

Development dropped abruptly in 1942, reflecting the lack of any sizable discoveries and the effect of the provisions of Federal Well Spacing Order M-68, which became effective in December 1941. In all, 1210 wells were drilled in 1942. This represents a decrease of 42.7 per cent from the 1941 total of 2110. Of the total wells completed, 553 (45.7 per cent) were oil wells with an average initial production of 443 bbl.; 102 (8.4 per cent) were gas wells with an average initial of 3,359,000 cu. ft.; and 555 (45.9 per cent) were dry.

Although the number of completions declined sharply, the total of 320 wildcats completed (26.4 per cent of all wells) represents a decrease of only 2.7 per cent from the previous year's figure of 329. Of the wildcats drilled, 44 (13.8 per cent) were oil wells, 13 (4.0 per cent) were gas wells, and 263 (82.2 per cent) were recorded as failures. Reconditioning of wells throughout the state resulted in a total recompletion of 355 wells. Of these, 234 were oil wells with a combined initial production of 96,808 bbl., 32 were gas wells with a total initial of 381,488,000 cu. ft., and 89 were abandoned.

None of the 26 pools found in 1942 has developed into a major discovery. The Pauls Valley pool, Garvin County, is the most outstanding. Since its discovery in April, 14 wells with an average initial of 1898 bbl. have produced 803,000 bbl. of 42° gravity oil from the Bromide zone. Development in this pool is believed to be almost completed.

Other of the more important discoveries are the East Watchorn pool, Pawnee County; Guthrie Townsite and West Navina, Logan County; Brooksville and Macomb, Pottawatomie County, and the Liberty and Northeast Lucien discoveries in Noble county. The East Watchorn pool, at the close of the year, had 14 completed oil wells with an average initial of 989 bbl. from the Wilcox sand at 3930 ft.; Guthrie Townsite, one well with an initial of 840 bbl. from dolomite at 5600 ft.; West Navina, six wells with an average initial of 284 bbl. in the Layton sand at 5050 ft.; Brooksville, eight wells in the Hunton at 4800 ft. with an average initial of 355 bbl.; Macomb, one well with an initial of 160 bbl. in the Hunton at 4700 ft.; the Liberty pool, one well with an initial of 1268 bbl. in the second Wilcox at 4500 ft., and two wells in the Tonkawa sand at 2500 ft., with an average initial of 230 bbl. In the Northeast Lucien pool, four wells were completed in the Wilcox at 5380 ft. for an average initial of 1164 bbl., and one well was completed in the Viola lime at 5255 ft. for an initial of 55 barrels.

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TABLE I.—*Oil and Gas Development in Oklahoma*

Line Number	Field, County	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
	CENTRAL OKLAHOMA												
1	Agra, West, *Lincoln*	1927	40	194,120	10,859					2			2
2	Avery, *Lincoln*	1939	120	10,558	2,992	4				3			3
3	Chandler, *Lincoln*	1924	1,255	12,127,572	209,039					40			40
4	Davenport, *Lincoln*	1924	2,335	12,129,376	161,068	222				114			114
5	North, *Lincoln*	1941	130	53,666	38,139	6				6			6
6	West, *Lincoln*	1940	80	98,817	40,204	5				5			5
7	Gessman, *Lincoln*	1934	160	407,767	21,317					9			9
8	Hoyt, *Lincoln*	1935	265	1,361,190	47,544	14				9			9
9	Kendrick, *Lincoln*	1940	40	43,798	7,719	1				1			1
10	Laffoon, *Lincoln*	1932	470	2,074,125	198,764	29	2			13			13
11	Lincreek, *Lincoln*	1932	275	242,192	12,410					8			8
12	Payson, *Lincoln*	1940	40	11,840	4,243	1				1			1
13	Peck, *Lincoln*	1926	160	519,664	65,138					5			5
14	Perkins, *Lincoln*	1940	150	197,236	35,069					4			4
15	Sac and Fox, *Lincoln*	1924–37	1,830	3,325,889	250,238					141			141
16	Skellyville, *Lincoln*	1925	750	1,794,817	24,331					12			12
17	Sporn, *Lincoln*	1936	150	721,583	59,037	10				6			6
18	East, *Lincoln*	1942	10	2,041	2,041	1	1			1			1
19	Stroud, *Lincoln*	1923	590	9,066,998	158,076	69				25			25
20	Wellston, North, *Lincoln*	1936	500	1,430,148	62,112					13			13
21	Wilzetta, *Lincoln*	1934	220	1,141,951	80,403	15				12			12
22	South, *Lincoln*	1936–42	80	209,999	54,749					4			4
23	Miscellaneous, *Lincoln*		240	729,274	23,003					9			9
24	Cleveland, *Pawnee*	1904	4,255	40,296,020	143,810		4			221			221
25	Greenup, *Pawnee*	1926		*y*					Abandoned				
26	Hallet, *Pawnee*	1922	1,665	*y*	25,550		2			45			45
27	Jennings, *Pawnee*	1916	1,375	4,039,757	66,795					76			76
28	Keystone, *Pawnee*	1919	5,565	2,635,129	132,860					223			223
29	Lauderdale, *Pawnee*	1915	4,300	13,602,675	213,160		1			184			184
30	Maramec, *Pawnee*	1920	1,990	3,118,207	155,490					86			86
31	Masham, *Pawnee*	1924	290	*y*	6,935					5			5
32	Pawnee, East, *Pawnee*	1941	10	8,731		2			Abandoned				
33	Ralston, *Pawnee*	1924	205	*y*	2,190					2			2
34	Skedee, *Pawnee*	1926	160	209,876	9,320		1			5			5
35	Terlton, *Pawnee*	1912	980	901,146	10,220					13			13
36	North, *Pawnee*	1917	2,010	3,218,962	52,560					71			71
37	Watchorn, *Pawnee*	1922	530	7,571,978	83,211					15			15
38	East, *Pawnee*	1942	780	431,132	431,132	14	14			14		*y*	*y*
39	Miscellaneous, *Pawnee*		280	*y*	12,233					7			7
40	Broyles, *Payne*	1918–39	170	*x*	25,185					6			6
41	East, *Payne*	1940		34,422			Abandoned during 1941						
42	Coyle, *Payne*	1938–40	1,338	4,181,667	1,661,480	36	1			36		*y*	*y*
43	North, *Payne*	1942	80	24,449	24,449	2	2			2			2
44	Garr, *Payne*	1920	1,135	2,596,420	120,085		1			32			32
45	Ingalls, *Payne*	1914	1,110	6,219,239	112,785					30			30
46	March, *Payne*	1922	1,410	*y*	30,660					18			18
47	North, *Payne*	1926	155	*y*	22,995					7			7
48	Markham, *Payne*	1928	260	58,497	27,010		3			4			4
49	Mehan, *Payne*	Prior to 1925	670	2,337,846	3,221					3			3
50	Northeast, *Payne*	1941	85	62,457	52,076	3	1			3			3
51	New Cushing, *Payne*	1916	185	*x*				Abandoned					
52	Norfolk, *Payne*	1916	785	*y*	77,380					19			19
53	West, *Payne*	1929	390	*y*	71,905					22			22
54	Orlando, *Payne*	1929	210	1,002,391	29,078					1		*y*	*y*
55	East, *Payne*	1941	80	141,990	86,056	3	1			3		*y*	*y*
56	Ramsey, *Payne*	1938–40	630	6,588,804	1,664,959	42				41		*y*	
57	Ripley, *Payne*	1923	375	*y*	15,330		1			5			5
58	North, *Payne*	1923	165	2,234,942	22,043					2			2
59	Stillwater, *Payne*	1935	130	527,871	9,125	6				3			3

[c] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
1												
2		44	Prue	Pen								
3		38	Various	Pen, Ord	S, L	Por	3,250	5,020		A		
4		43	Various	Pen	S	Por	2,600	3,580	50	ML		
5		41	Prue	Pen			3,535	3,548	13			
6		46	Prue	Pen								
7		44	Cleveland	Pen	S	Por	y	y		M		
8		40	1st Wilcox	Ord	S	Por	y	5,100	y			
9		50	Prue	Pen								
10		21	Wilcox	Ord	S	Por	4,190	4,275		A	Wilcox	
11		46	Wilcox	Ord	S	Por	y	y				
12		35	Lower Skinner	Pen								
13		23	2nd Wilcox	Ord								
14		43	Hunton	Sil								
15		46	Prue	Pen	S							
16		41	Various	Pen, Sil, Ord, Cam	S, L							
17		46	Simpson	Ord	S		4,500	4,600	y			
18			Upper Simpson, Wilcox	Ord	S		4,555		10			
19		41	Various	Pen, Ord	S	y	4,240	4,290	50		Wilcox	4,520
20		40	Wilcox	Ord	S							
21		40	Hunton, Viola	Sil-Dev, Ord								
22		35	Hunton, Viola, Bartlesville	Sil-Dev, Ord, Pen								
23		40	Prue, Wilcox	Pen, Ord	S							
24		36	Various	Pen, Ord, Cam	S, L	Por	1,300	2,400				
25												
26		38	Various	Pen, Ord								
27		37	Various	Pen, Mis, Ord	S, L	y	y	y				
28		37	Various	Pen, Mis, Ord	S, L		1,100	1,970				
29		37	Various	Pen, Ord, Cam	S, L		1,185	3,000				
30		37	Various	Pen			2,400	3,200				
31		39	Various	Pen, Mis, Ord	S, L							
32		42	Misener	Mis			3,363	3,367	4			
33		39	Various	Pen, Ord								
34		40	Bartlesville, Burgess, Skinner	Pen	S							
35		38	Various	Pen, Ord								
36		38	Various	Pen, Ord				y	y			
37		41	Various	Pen, Mis, Ord	S, L	Por						
38		43	Wilcox	Ord	S		3,880		15			
39		37	Bartlesville, Wilcox	Pen, Ord	S							
40		43	Bartlesville, Viola, Wilcox	Pen, Ord	S, L							
41		36										
42		46	Hunton, Wilcox	Sil, Ord	S, L	y	y	y	y			
43		41	Hunton	Sil-Dev	L		4,751		9			
44		38	Various	Pen, Mis, Ord	S, L							
45		39	Various	Pen, Mis, Ord	S, L		3,115	3,760				
46		38	Various	Pen, Ord								
47		43	Wilcox	Ord	S							
48		43	Burgess Sd-Miss Ls	Pen-Mis	S, L		3,266		13			
49		43	Various	Pen, Mis, Sil-Dev, Ord								
50		38	1st and 2nd Wilcox	Ord			4,065 4,100	4,076 4,103	11 3			
51		38	Various	Pen, Ord								
52		38	Bartlesville, Wilcox	Pen, Ord	S							
53		38	Bartlesville, Wilcox	Pen, Ord	S							
54		41	Misener	Mis	S							
55		42	Misener	Mis	S		4,720	4,747	27			
56		43	1st Wilcox	Ord	S		4,768	4,795	27			
57		43	Various	Pen, Ord	S, L							
58		43	Wilcox	Ord	S	Por	y	y	y	y		
59		40	Wilcox	Ord	S	Por	4,300	4,306	6	A		

TABLE 1.—(*Continued*)

Line Number	Field, County	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
60	West, *Payne*	1940	150	155,361	37,430	2				2			2
61	Yale-Quay, *Payne*	1914	4,095	22,674,187	566,115					161			161
62	Miscellaneous, *Payne*		160	*y*	22,361					4			4
63	Aggregate for district of pools marked *x* or *y*			5,596,509									
64	Total Central Oklahoma		48,053	178,365,286	7,595,689					1,815			
	EAST CENTRAL OKLAHOMA												
65	Hoffman, *McIntosh*	1917	300	*x*	1,825					3			3
66	Miscellaneous, *McIntosh*		10	42						1			1
67	Beland, *Muskogee*	1906	390	*x*	3,650					9			9
68	Boyle, *Muskogee*	1927	230	*y*	12,410					15			15
69	Boynton, *Muskogee*	1914	2,740	*x*	14,600					21			21
70	Butler, *Muskogee*	1918	1,500	*x*	27,740					60			60
71	Cole, *Muskogee*	1914	780	*x*	5,840					17			17
72	Council Hill, *Muskogee*	1919	335	*x*	34,310					30			30
73	Haskell, *Muskogee*	1909	1,750	*x*	29,565					77			77
74	Jolly-Patton, *Muskogee*	1920	260	*y*	0					20			20
75	Link, *Muskogee*	1909	715	*x*	55,115					34			34
76	Muskogee, *Muskogee*	1904	3,760	*x*	59,860					111			111
77	North, *Muskogee*	1906	290	*x*	0					22			22
78	Robinson, *Muskogee*	1915		*x*	0					2			2
79	Sheppard, *Muskogee*	1917	140	*x*	2,555					1			1
80	Sommerville, *Muskogee*	1926		*y*						Abandoned			
81	Transcontinental, *Muskogee*	1918	215	*x*	2,920					8			8
82	Yahola, *Muskogee*	1914	680	*x*	9,490					18			18
83	Miscellaneous, *Muskogee*		820	*x*	6,630					10			10
84	Baltimore, North, *Okfuskee*	1922	525	*y*	2,920		1			3			3
85	Bearden, *Okfuskee*	1924		*y*						Abandoned			
86	Beidleman, *Okfuskee*	1930	100	271,628	7,022					6			6
87	Blakley, *Okfuskee*	1924	110	852,962	9,916					2			2
88	Cary, *Okfuskee*	1923	485	1,129,237	23,915					10			10
89	Clearview, *Okfuskee*	1927	240	*y*	22,265					10			10
90	Clearview, Northeast, *Okfuskee*	1942	40	1,147	1,147	1	1			1			1
91	Cowan, *Okfuskee*	1940	80	25,690	7,529					1			1
92	Deaner, *Okfuskee*	1920	1,460	*y*	89,060					81			81
93	Fields, *Okfuskee*	1918	460	*x*	10,585					10			10
94	Gregory, *Okfuskee*	1922	390	*y*	25,550		2			14			14
95	Gypsy Hill, *Okfuskee*	1910	1,603	*x*	22,265		1			20			20
96	Haydenville, *Okfuskee*	1939	240	92,953	20,017					4			4
97	Josey, *Okfuskee*	1923	525	*y*	55,845					19			19
98	Keaton, *Okfuskee*	1919		*x*						Abandoned			
99	Lyons-Quinn, *Okfuskee*	1921	1,645	*y*	46,355					23			23
100	Mason, *Okfuskee*	1940	80	8,515	186	2				2			2
101	Micawber, *Okfuskee*	1923	160	*y*	4,745					1			1
102	Midwest, *Okfuskee*	1942	40	26,429	26,429	1	1			1			1
103	Morgan, *Okfuskee*	1923	340	*y*	2,555					1			1
104	Okemah, *Okfuskee*	1921	1,050	*y*	96,360					50			50
105	East, *Okfuskee*	1940	160	293,785	112,227	10				9			9
106	North, *Okfuskee*	1941–42	160	98,256	70,109	9	6			9			9
107	West, *Okfuskee*	1941	120	44,309	5,184	5				4			4
108	Okfuskee, *Okfuskee*	1938	100	125,947	12,453					5			5
109	Paden, *Okfuskee*	1914	80	*x*	5,110					3			3
110	Sheldon, *Okfuskee*	1916	900	*x*	40,150					16			16
111	Weleetka, *Okfuskee*	1913	1,815	*x*	206,590					74			74
112	South, *Okfuskee*	1937	90	59,168	1,718					3			3
113	West, *Okfuskee*	1926	250	867,212	174,101					15			15
114	Miscellaneous, *Okfuskee*		340	*x*	16,279					4			4
115	Aztec, *Okmulgee*	1917	2,140	*x*	59,130		1			57			57
116	Bald Hill, *Okmulgee*	1908	25,095	*x*	365,365					767			767
117	Beets-Rapp, *Okmulgee*	1920		*y*						Abandoned			
118	Beggs, North, *Okmulgee*	1909	1,840	*x*	17,155					30			30
119	Beggs, South, *Okmulgee*	1911	4,455	*x*	71,540					49			49
120	Brinton, *Okmulgee*	1914	545	*x*	14,965					18			18
121	Coalton, *Okmulgee*	1907	2,040	*x*	21,170					67			67

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
60		40	Hunton	Sil								
61		38	Oswego, Bartlesville, Wilcox	Pen, Ord	S, L		2,670	3,580				
62		39	1st and 2nd Wilcox	Ord								
63												
64												
65		35	Wilcox	Ord	S							
66												
67		35	1st and 2nd Dutcher	Pen	S							
68		38	Dutcher	Pen	S							
69		35	Mississippian	Mis	L							
70		32	Unidentified sand									
71		35	Unidentified sand									
72		38	Various	Pen								
73		34	Tucker	Pen								
74		33	Muskogee, Timber-Ridge									
75		36	Booch, Dutcher	Pen								
76		38	Unidentified sand, Wilcox	Ord	S		1,052	1,790				
77		35	Wilcox	Ord	S							
78		39	Muskogee									
79		39	Unidentified sand									
80												
81		39	Booch	Pen	S							
82		39	Booch, Boynton	Pen								
83		38	Leidecher, Dutcher, Wilcox	Pen, Ord								
84		38	Dutcher, 1st and 2nd Wilcox	Pen, Ord								
85												
86		38	Wilcox	Ord	S							
87		39	Unidentified sand									
88		32	Various	Pen								
89		38	Wilcox	Ord	S							
90		39	Gilcrease	Pen	S		2,915		10			
91		42	Hunton	Sil-Dev								
92		38	Deaner, Lyons, Wilcox	Pen, Ord	S		2,800	3,650				
93		43	Deaner, Wilcox	Pen, Ord	S							
94		39	Various	Pen, Ord								
95		33	Youngstown, Dutcher, Wilcox	Pen, Ord	S		2,430	3,290				
96		31	Dutcher, Wilcox	Pen, Ord	S							
97		40	Wilcox	Ord	S		3,600	3,650	50	D	Wilcox	3,700
98		39	Dutcher, Quin	Pen								
99		39	Lyons	Pen								
100		39	Hunton	Sil-Dev								
101		36	Wheeler, Dutcher	Pen								
102		36	Hunton	Sil Dev	L		3,692		4			
103		37	Dutcher	Pen								
104		30	Gilcrease, Cromwell	Pen								
105		37	Lower Cromwell	Pen								
106		35	Gilcrease, Hunton	Pen, Sil-Dev								
107		Dist.	Hunton	Sil-Dev			3,916	3,960	44			
108		39	Dutcher, Wilcox	Pen, Ord								
109		36	Prue	Pen	S							
110		42	Wilcox	Ord								
111		39	Gilcrease	Pen	S		2,530	2,660	130			
112		39	L. Gilcrease	Pen	S							
113		41	Booch	Pen	S							
114		36	Various	Pen, Ord								
115		38	Booch, Wilcox	Pen, Ord	S							
116		30	Glenn	Pen	S		750	2,250				
117												
118		38	Youngstown, Wilcox	Pen, Ord								
119		37	Various	Pen, Mis, Ord								
120		37	Wilcox	Ord	S							
121		30	Booch, Wilcox	Pen, Ord	S		1,300	2,835				

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres: Oil	Total Oil Production, Bbl.: To End of 1942	Total Oil Production, Bbl.: During 1942	Number of Oil and/or Gas Wells: Completed to End of 1942	During 1942: Completed	During 1942: Abandoned	End of 1942: Temporarily Shut Down	End of 1942: Producing Oil[c]	End of 1942: Producing Gas[c]	Oil-production Methods, End of 1942, Number of Wells: Flowing	Oil-production Methods, End of 1942, Number of Wells: Artificial Lift
122	Edna, East, *Okmulgee*	1919	150	*x*	3,285					2			2
123	Eram, *Okmulgee*	1921	600	*y*	4,380					14			14
124	Gypsy Hill, Northwest, *Okmulgee*	1938	100	60,665	7,899					5			5
125	Hamilton Switch, *Okmulgee*	1909	2,570	*x*	30,295					75			75
126	Hector, *Okmulgee*	1914	645	*x*	2,555					7			7
127	Henryetta, *Okmulgee*	1910	785	*x*	9,855					33			33
128	Montezuma, *Okmulgee*	1918	220	*x*	5,840					4			4
129	Morris, *Okmulgee*	1907	7,300	*x*	123,370					227			227
130	Natura District, *Okmulgee*	1914	1,750	*x*	12,775					18			18
131	Nuyaka, South, *Okmulgee*	1937	105	503,225	32,867					6			6
132	Nuyaka, Southwest, *Okmulgee*	1941	40	20,311	5,576	2				2			2
133	Oklahoma Central, *Okmulgee*	1921	545	*y*	10,585					8			8
134	Okmulgee, *Okmulgee*	1906	5,020	*x*	54,020					136			136
135	Phillipsville, *Okmulgee*	1920	580	*y*	7,300					7			7
136	Pine, *Okmulgee*	1915	815	*x*	6,935					26			26
137	Pollyanna, *Okmulgee*	1921	3,975	*y*	119,720		3			208			208
138	Schulter, *Okmulgee*	1907	455	*x*	5,110					10			10
139	Simmons-Black, *Okmulgee*	1920	455	*y*	37,595					12			12
140	Spencer, *Okmulgee*	1917	790	*x*	22,265					35			35
141	Summers, *Okmulgee*	1914	290	*x*	3,650					15			15
142	Tiger Flats, *Okmulgee*	1928	1,045	*y*	0		1		Abandoned				
143	Youngstown, *Okmulgee*	1915	2,235	*x*	28,835					44			44
144	Miscellaneous, *Okmulgee*		465	*x*	8,611					9			9
145	Airport, *Tulsa*	1937	330	141,956	2,082					13			13
146	Alsuma, *Tulsa*	1916	850	*x*	3,650					5			5
147	Bird Creek, *Tulsa*	1906	17,910	*x*	409,165					1,552			1,552
148	Bixby, *Tulsa*	1916	1,860	*x*	35,405					69			69
149	Broken Arrow, *Tulsa*	1901	3,665	*x*	32,120					57			57
150	Bruner Vern, *Tulsa*	1923	1,055	*y*	43,800					51			51
151	Collinsville, *Tulsa*	1916	120	*x*	3,285					10			10
152	Dawson, *Tulsa*	1906	765	*x*	10,220		1			40			40
153	Fisher, *Tulsa*	1918	685	*x*	2,920					7			7
154	Jenks, *Tulsa*	1901	6,885	*x*	84,315					308			308
155	Leonard, *Tulsa*	1916	1,000	*x*	21,170					32			32
156	Owasso, *Tulsa*	1913	360	*x*	7,300					24			24
157	Perryman, *Tulsa*	1924	345	*y*	1,825					10			10
158	Red Fork, *Tulsa*	1901	4,390	*x*	22,630					80			80
159	Sand Springs, *Tulsa*	1916	625	*x*	20,805					45			45
160	Tulsa, *Tulsa*	1901	910	*x*	394					1			1
161	Turkey Mountain, *Tulsa*	1922	1,115	*y*	41,975					46			46
162	Turley, *Tulsa*	1914	3,715	*x*	81,030					354			354
163	Wicey, *Tulsa*	1915	2,200	*x*	58,035					91			91
164	Bilby, *Wagoner*	1918	260	*x*	6,935					7			7
165	Corine, *Wagoner*	1919	190	*x*	2,555					7			7
166	Coweta, *Wagoner*	1914	720	*x*	10,220					23			23
167	George, *Wagoner*	1918	270	*x*	12,410					32			32
168	Gillette, *Wagoner*	1924	65	*x*	1,825					8			8
169	Goble, *Wagoner*	1916	325	*x*	9,490					17			17
170	Johnson-Bailey, *Wagoner*	1920	80	*y*	0				Abandoned				
171	McCracken, *Wagoner*	1920	90	*y*	1,460					12			12
172	Oak Grove, *Wagoner*	1920	145	*y*	730					2			2
173	O.K., *Wagoner*	1919		*x*	0				Abandoned				
174	Oneta, *Wagoner*	1916	695	*x*	28,835					57			57
175	Seltzer, *Wagoner*	1924	65	*y*	2,190					11			11
176	Stone Bluff, *Wagoner*	1915	1,065	*x*	129,575					157			157
177	Striker, *Wagoner*	1917		*x*					Abandoned				
178	Wagoner, *Wagoner*	1914	460	*x*	730					43			43

TABLE I.—(*Continued*)

Line Number	Repressuring Operations[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
122		30	Unidentified sand									
123		40	Wilcox	Ord	S							
124		43	Wilcox	Ord	S		3,250		10			
125		29	Glenn, Dutcher, Wilcox	Pen, Ord	S		1,385	2,700				
126		37	Various	Pen, Mis, Ord	S, L							
127		38	Various	Pen, Sil-Dev, Ord, Cam	S, L							
128		38	Unidentified sand									
129		36	Various	Pen, Mis, Ord	S, L		1,600	2,450				
130		30	Various	Pen, Mis, Ord								
131		42	Wilcox	Ord	S							
132		38	Misener	Mis			3,168	3,176	8			
133		32	Wilcox	Ord	S							
134		30	Various	Pen, Mis, Ord	S		1,240	2,750				
135		45	Wilcox	Ord	S							
136		35	Booch, Dutcher	Pen	S							
137		34	Various	Pen, Ord, Cam	S, L		1,365	2,285				
138		36	Deaner, Glenn, Wilcox	Pen, Ord								
139		36	Salt, Booch	Pen								
140		33	Various	Pen, Mis, Ord, Cam								
141		38	Dutcher	Pen	S							
142		37	Various	Pen, Ord								
143		31	Youngstown	Pen	S							
144		40	Booch, Dutcher, Wilcox	Pen, Ord	S							
145		38	Bartlesville	Pen	S							
146		35	Burgess	Pen	S							
147		31	Bartlesville, Wilcox	Pen, Ord	S		1,110	1,345				
148		32	Various	Pen, Ord	S, L							
149		37	Various	Pen, Mis, Ord, Cam	S, L		1,350	1,500				
150		37	Various	Pen, Ord, Cam								
151		33	Various	Pen, Mis	S, L							
152		36	Bartlesville, Tucker	Pen	S							
153		34	Oswego, Tyner, Arbuckle	Pen, Ord, Cam								
154		36	Various	Pen, Mis Ord, Cam	S, L							
155		35	Various	Pen, Mis, Ord, Cam	S, L							
156		30	Various	Pen, Ord, Cam								
157		31	Unidentified sand									
158		34	Various	Pen, Ord, Cam			599	2,160				
159		37	Various	Pen, Ord, Cam								
160		34	Various	Pen, Mis, Ord								
161		35	Various	Pen, Ord, Cam								
162		32	Bartlesville, Burgess, Siliceous	Pen, Ord, Cam	S, L		1,260	1,945				
163		37	Various	Pen, Mis, Ord	S, L		1,480	1,950				
164		35	Dutcher, Burgess	Pen								
165		39	Unidentified sand									
166		38	Various	Pen, Mis, Ord, Cam	S, L		700	1,280				
167		36	Dutcher	Pen	S							
168		38	Tyner	Ord								
169		37	Dutcher	Pen	S							
170		33	Unidentified sand									
171		43	Tyner	Ord								
172		33	Pitkin, Burgen	Pen, Ord								
173		36	Dutcher, Tyner, Burgen	Pen, Ord								
174		38	Dutcher, Mississippi, Tyner	Pen, Mis, Ord	S, L		1,000	1,200				
175		37	Dutcher	Pen	S							
176		36	Various	Pen, Mis. Ord, Cam			1,840	2,275				
177			Dutcher, Morrow-Pitkin	Pen, Mis								
178		35	Peru, Ordivician	Pen, Ord								

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
179	South, *Wagoner*	1939	80	9,026	2,168					5			5
180	Webster, *Wagoner*	1917	60	*x*	2,555					11			11
181	Wright, *Wagoner*		80	*y*	362					1			1
182	Miscellaneous, *Wagoner*		170	*y*	3,650					7			7
183	Aggregate for district of pools marked *x* or *y*			307,831,063									
184	Total East Central		149,158	312,463,526	3,575,561					5,946			5,946
	EAST CENTRAL (CREEK COUNTY)												
185	Arno	1923	210	*y*	46,355					17			17
186	West	1940	227	105,700	43,719	8	1			5			5
187	Bellview	1941	50	49,895	34,311					6			6
188	Big Pond	1924	470	*y*	130,670					33			33
189	Bowden	1906	3,495	*x*	124,465					215			215
190	Bristow	1916	5,255	*x*	303,680					132			132
191	Bristow, North	1922	1,700	*y*	121,910					101			101
192	Bristow, West	1922	565	*y*	27,010					15			15
193	Bruce	1926	515	*y*	36,865					39			39
194	East	1939	100	*y*	8,395					8			8
195	Cushing	1912	24,940	362,427,716	3,068,139	3,677	9			1,736			1,736
196	Deep Fork	1920	3,345	*y*	121,180		1			119			119
197	Depew	1915	1,365	*x*	381,060		1			74			74
198	Donnelly	1924	730	*y*	87,965					34			34
199	Edna	1940	90	82,887	24,915					5			5
200	Glenn pool	1905	15,970	222,075,004	1,480,951		20			1,750			1,750
201	Hickory Grove	1942	80	38,933	38,933	10	10			9			9
202	Independent	1908	1,320	*x*	48,180					31			31
203	Iron Post	1917	925	*x*	27,740					55			55
204	Kellyville	1934	3,600	*y*	147,825					196			196
205	Mannford (deep and shallow)	1922–37	4,650	*y*	294,920					232			232
206	Mercer	1923	80	293,771	10,009					4			4
207	Milfay	1941	640	45,442	41,853	2	1			2			2
208	Mounds	1915	1,580	*x*	33,945					43			43
209	Newby	1929	80	*y*	4,745					4			4
210	Olean	1921	340	*y*	26,280					18			18
211	Olive	1914	2,235	*x*	123,005					191			191
212	Olive, South	1940	20	2,183	737	1				1			1
213	Pickett-Prairie	1916	1,820	*x*	14,235					56			56
214	Poor Farm	1920	340	*y*	16,060					13			13
215	Red Bank	1918	370	*x*	22,265					8			8
216	Sapulpa	1909	1,790	*x*	66,430					106			106
217	South	1910	2,570	*x*	96,725					70			70
218	Slick	1913	6,585	*x*	466,835					167			167
219	Stroud, East	1940	460	699,634	192,261	45				45			45
220	Tibbens	1924	430	*y*	20,805					36			57
221	North	1940	110	62,078	21,253	4				4			4
222	Tuskegee	1924	310	*y*	6,205		1			8			8
223	East	1925	540	1,109,867	127,663					31			31
224	Walker	1923	390	*y*	73,365		1			26			26
225	West	1939	80	110,425	16,438					7			7
226	Wilcox	1919	1,375	*x*	174,470					53			53
227	Miscellaneous		280	*y*	21,535					9			9
228	Aggregate for district of pools marked *x* or *y*			195,863,635									
229	Total East Central (Creek County)		92,027	782,967,170	8,176,307					5,714			5,714

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
179		36	Pennsylvanian									
180		33	Burgen	Ord								
181		39	Pitkin	Pen	L							
182		32	Unidentified sand and lime									
183												
184												
185		36	Simpson	Ord								
186		40	Prue, Red Fork, Bartlesville, Wilcox	Pen, Ord								
187		36	Red Fork Sd	Pen	S		2,756		10			
188		32	Jones, Glenn, Dutcher, Wilcox	Pen, Ord	S							
189		32	Taneha	Pen								
190		35	Layton, Ft. Scott, Oswego, Red Fork, Bartlesville, Dutcher, Miss., Wilcox	Pen, Mis, Ord	S, L		2,700	3,200				
191		35	Layton, Ft. Scott, Oswego, Red Fork, Bartlesville, Dutcher, Miss., Wilcox	Pen, Mis, Ord	S, L							
192		35	Dutcher	Pen			3,152	3,155				
193		35	Layton, Ft. Scott, Oswego, Red Fork, Bartlesville, Dutcher, Miss., Wilcox	Pen, Mis, Ord								
194		37	Layton	Pen								
195		39	Various	Pen, Ord	S, L	Por			*x*	AF		
196		42	Layton, Peru, Prue, Dutcher	Pen								
197		32	Glenn, Dutcher, Wilcox	Pen, Ord	S		2,700	3,397				
198		37	Dutcher, 1st Wilcox	Pen, Ord								
199		35	Wilcox	Ord								
200	RP	34	Various	Pen, Ord								
201		48	Bartlesville	Pen	S		3,119		11			
202		35	Taneha, Wilcox	Pen, Ord	S		2,100	2,550				
203		36	Wheeler, Prue, Cleveland	Pen	S		2,420	2,475				
204		30	Peru	Pen	S							
205		34	Various	Pen, Ord	S, L		1,550	2,980				
206		41	Dutcher, Wilcox	Pen, Ord	S							
207		35	1st & 2nd Wilcox	Ord	S		3,970		5			
208		33	Red Fork, Glenn, Tucker, Dutcher, Wilcox	Pen, Ord	S		400	2,400				
209		34	Dutcher	Pen	S							
210		40	Layton, Peru, Wheeler, Skinner, Bartlesville	Pen	S							
211		36	Various	Pen	S							
212		38	Prue	Pen								
213		35	Glenn, Taneha, Wilcox	Pen, Ord								
214		34	Various	Pen								
215		36	Various	Pen, Ord								
216		34	Various	Pen, Mis, Ord	S, L		1,000	2,290				
217		36	Taneha, Dutcher, Wilcox	Pen, Ord								
218		32	Various	Pen, Mis, Ord			2,340	3,088			Wilcox	3,140
219		41	2nd Wilcox	Pen, Ord								
220		34	Various									
221		39	Wilcox	Ord								
222		38	Various	Pen, Ord								
223		39	Various	Pen, Mis, Ord								
224		35	Various	Pen, Mis, Ord	S, L							
225		37	Bartlesville	Pen	S							
226		35	Various	Pen, Ord								
227		39	Prue, Bartlesville, Wilcox	Pen, Ord	S							
228												
229												

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift
	NORTHEASTERN OKLAHOMA												
230	Craig, Nowata, Rogers, and Washington Counties		104,670	359,763,692	5,920,300					14,907			14,907
	NORTHERN OKLAHOMA												
231	Barnes, *Garfield*	1918	185	*x*	11,680					10			10
232	Brown, *Garfield*	1930	85	439,326	15,217					4			4
233	Enid, *Garfield*	1940	240	56,180	18,656					2			2
234	Garber, *Garfield*	1916	4,520	55,757,897	611,013	979	6			539			539
235	North, *Garfield*	1927	90	*y*	7,665					5			5
236	Hillsdale, *Garfield*	1938	160	96,405	9,700					1			1
237	Waukomis, *Garfield*	1938		35,044		1			Abandoned				
238	Miscellaneous, *Garfield*	1926	40	64,719	3,559					2			2
239	Caldwell, *Grant*	1929	80	269,325	2,842					2			2
240	Deer Creek, *Grant*	1922	210	1,331,577	33,580		1			10			10
241	Lamont, *Grant*	1937	60	781,695	57,037	3				1			1
242	Webb, *Grant*	1926	120	223,223	10,671					4			4
243	Blackwell, *Kay*	1918	1,750	5,297,850	145,731					40			40
244	Braman, *Kay*	1924	335	4,720,008	67,525					23			23
245	North, *Kay*	1924	795	18,448,022	208,780					45			45
246	Southeast, *Kay*	1938	440	403,142	126,108					4			4
247	Dilworth, *Kay*	1917	2,355	5,552,309	282,875					77			77
248	Hubbard, *Kay*	1924	645	8,521,368	137,240					36			36
249	Mervine, *Kay*	1913	960	*x*	12,045					2			2
250	Newkirk, *Kay*	1919	250	*x*	25,185					6			6
251	Ponca City, *Kay*	1917	1,445	6,498,379	86,140					40			40
252	Thomas, *Kay*	Prior to 1914	275	7,266,801	76,103					13			13
253	Tonkawa, *Kay*	1921	3,695	121,962,023	593,688	929				170			170
254	South, *Kay*	1921		*x*					Abandoned				
255	Vernon, *Kay*	1925	660	3,462,523	125,925		4			21			21
256	Miscellaneous, *Kay*		290	*x*	8,944					5			5
257	Crescent, *Logan*	1933	1,820	14,204,265	733,637	68	14			45			45
258	Crescent South, *Logan*	1942	40	8,586	8,586	1	1			1			1
259	Guthrie, *Logan*	1941	620	1,929,325	1,150,879	32	4			32		*y*	*y*
260	Guthrie Townsite, *Logan*	1942	400	43,365	43,365	1	1			1		1	
261	Hull, *Logan*	1934	80	237,478	7,665					2			2
262	Langston, *Logan*	1934	340	1,679,420	225,633		2			16			16
263	South, *Logan*	1935	90	49,925	2,493					1			1
264	Lovell, *Logan*	1928	220	2,701,797	45,260		2			8			8
265	South, *Logan*	1934	440	422,908	138,584		1			7			7
266	West, *Logan*	1936		95,176		2			Abandoned				
267	Marshall, *Logan*	1927	740	11,826,310	49,275					21			21
268	Meridian, *Logan*	1938	240	169,472	14,210	7				3			3
269	Navina, *Logan*	1941	20	475	341	1				1			1
270	Navina, West, *Logan*	1942	320	147,417	147,417	6	6			6		*y*	*y*
271	Seward, *Logan*	1936	40	83,138	8,730					1			1
272	Billings: Deep, *Noble*	1935	1,150	13,333,127	2,061,520	79				73		*y*	*y*
273	Shallow, *Noble*	1917	590	6,209,529	13,783					7			7
274	Liberty, *Noble*	1942	120	118,244	118,244	3	3			3		3	
275	Liberty, East, *Noble*	1942	120	49,061	49,061	1	1			1		1	
276	Lucien, *Noble*	1932	4,170	29,901,007	1,477,554	130	2			120			120
277	North, *Noble*	1936	530	1,127,830	191,760		2			11			11
278	Lucien, Northeast, *Noble*	1942	240	121,841	121,841	5	5			5		*y*	*y*
279	Marathon, *Noble*	1935		138,341		Abandoned during 1941							
280	Morrison "A", *Noble Co*	1942	40	0	0	1	1			1			1
281	Otoe City, *Noble*	1930	240	219,637	74,304		2			6			6
282	Perry, *Noble*	1923	60	83,840	4,938					1			1
283	Polo, *Noble*	1934	510	4,310,387	240,341	37				28			28
284	Sams, *Noble*	1925	295	*y*	19,345					8			8
285	Aggregate for district of pools marked *x* or *y*			5,617,374									
286	Total Northern Oklahoma		33,160	336,017,091	9,626,675					1,470		*y*	*y*

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
230		36										
231		39	Tonkawa, Layton	Pen								
232		39	Wilcox	Ord	S							
233		40	Mississippian	Mis	L							
234		41	Various	Per, Pen, Ord	S, L	Por	1,100	4,200	y		y	y
235		44	Various	Pen, Ord								
236		39	1st and 2nd Wilcox	Ord	S		y	y			y	y
237		53	Marshall Zone		S	y	7,260	7,280	20		y	y
238		43	Wilcox	Ord	S	Por	y	y	6	A	y	y
239		40										
240		38	Various	Pen, Mis, Ord	S, L		2,900	4,175	y			
241		40	Wilcox	Ord	S	y	5,400	5,410	10		y	y
242		42	Various	Pen, Mis, Ord								
243		40	Various	Pen, Ord	S, L		1,600	3,440				
244		40	Various	Pen, Ord	S, L							
245		41	Various	Pen, Ord	S, L							
246		40	Arbuckle, Wilcox	Cam-Ord, Ord	S	y	y	y	y		y	y
247		40	Blackwell, Wilcox	Pen, Ord					y	A		
248		37	Various	Pen, Ord		Por	y	y	y	AF	y	y
249		39	Various	Pen								
250		40	Burbank, Mississippian	Pen, Mis								
251		38	Various	Pen, Mis, Ord	S, L		1,500	3,900		A		
252		41	Various	Per, Pen, Ord	S, L	Por			y	x		
253		42	Various	Pen, Mis, Ord	S, L	Por	2,660	4,075	y	x		
254			Endicott, Tonkawa, Wilcox	Pen, Ord								
255		40	Various	Pen, Mis, Ord	S, L				y	x		
256		39	Various									
257		41	Layton, Wilcox, 2nd Wilcox	Pen, Ord	S	23				AF		
258		43	Layton	Pen	S		5,237		26			
259		46	Bartlesville, 2nd Wilcox	Pen, Ord			5,109 5,425	5,123 5,445	14 20			
260		43	Dolomite, Wilcox	Ord	S		5,604		8			
261		40	Layton, Tonkawa, Wilcox	Pen, Ord	S	Por		4,800				
262		39	Wilcox	Ord	S	Por	5,100	5,145		A	Wilcox	5,190
263		40	Upper Simpson	Ord								
264		40	Tonkawa, Wilcox	Pen, Ord	S	y	y	y				
265		49	Layton	Pen								
266		40	2nd Wilcox	Ord	S	Por	y		y	y		
267		41	Tonkawa, Wilcox, L Simpson	Pen, Ord	S	y	y	y	y			
268		48	Wilcox	Ord	S	y	5,200	5,220	20			
269		37	1st Wilcox	Ord			6,220	6,250				
270		42	Layton	Pen	S		5,010		33			
271		38	Simpson dolomite	Ord	D							
272		41	Wilcox	Ord	S	Por	4,250	y	y	A		
273		41	Various	Pen	S, L	Por			50	A		
274		43	Tonkawa, Wilcox	Pen-Ord	S		2,374 4,508		10 20			
275		45	Wilcox	Ord	S		4,508		20			
276		42	Various	Pen, Ord	S, L	Por	y	5,200	y	y		
277		41	Wilcox	Ord	S	Por	y	y	y	y		
278		40	2nd Wilcox	Ord	S		5,389		10			
279		42	Wilcox	Ord	S	Por	y	y	34	A		
280			Miss Ls	Mis	L		4,050		10			
281		39	Layton, Wilcox	Pen, Ord	S	Por	3,284	3,314	30	y		
282		41	Tonkawa, Reagan	Pen, Ord								
283		41	Various	Pen, Ord	S	y	4,823	4,900	y	y		
284		42	Tonkawa	Pen	S		1,902	1,912	10			
285												
286												

TABLE 1.—(*Continued*)

Line Number	Field, County	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
	OKLAHOMA CITY AREA												
287	Moore, *Cleveland*	1935	940	8,656,183	291,270	40				22			22
288	Noble, *Cleveland*	1938	195	74,489	12,591	2				1			1
289	Norman, *Cleveland*	1939	60	12,267	3,800					1			1
290	Britton, *Oklahoma*	1935	1,245	2,526,208	102,696					21			21
291	South, *Oklahoma*	1938	195	170,235	21,677	2				2			2
292	Edmond, *Oklahoma*	1930	1,560	19,078,833	1,052,916					78			78
293	Edmond, Northeast, *Oklahoma*	1941	195	112,242	91,479	11	10			11			11
294	Jones, *Oklahoma*	1939	250	133,752	51,163		1			4			4
295	Newalla, South, *Oklahoma*	1939	80	24,137	210					1			1
296	Nicoma Park, *Oklahoma*	1929	80	353,385	7,137	2				2			2
297	Oklahoma City, *Oklahoma*	1928	15,500	582,452,189	26,309,914	1,560	18			870			870
298	Miscellaneous, *Oklahoma*		160	16,743	9,113					2			2
299	Total Oklahoma City Area		20,460	613,610,663	27,953,966					1,015			1,015
	OSAGE COUNTY												
300	Almeda	1918	1,205	*x*	8,395					69			69
301	Atlantic	1924	1,330	*y*	305,140					88			88
302	Avant	1904	12,520	*x*	780,735					749			749
303	West	1905	3,555	*x*	51,830					157			157
304	Backius	1919	850	*x*	9,125					32			32
305	Bandwheel	1921	630	*y*	36,865					39			39
306	Barker	1932	240	*y*	34,310					11			11
307	Barnsdall	1916	3,620	*x*	72,635					208			208
308	Barnsdall, South	1921	1,125	*y*	27,010					85			85
309	Barnsdall, West	1922	1,665	*y*	182,500					111			111
310	Bartlesville	1904	16,335	*x*	18,615					81			81
311	Big Horse	1927	335	*y*	4,380					23			23
312	Birch Creek	1920	830	*y*	9,125					47			47
313	Boston	1904	770	*x*	112,420					37			37
314	Boston, West	1941	200	67,361	59,578					4			4
315	North	1921	240	*y*	17,885					9			9
316	Bowring	1921	160	*y*	3,285					12			12
317	Branstetter	1928	420	*y*	22,995					25			25
318	Buell	1922	100	*y*	8,760					9			9
319	Bulldog	1920	465	*y*	32,485					31			31
320	Burbank (*Osage and Kay*)	1920	24,665	208,520,615	3,357,523	2,204				1,695			1,695
321	South	Or. 1926 Ext. 1934	4,465	33,502,955	2,727,159	287				223			223
322	Candy Creek	1920	1,420	*y*	67,525					55			55
323	Canyon Creek	1923	160	*y*	59,130					6			6
324	Country Club	1923	515	*y*	26,280					30			30
325	Dalton	1926	205	*y*	3,285					3			3
326	Dewey	1904	4,920	*x*	20,440					108			108
327	Domes	1917	3,740	*x*	78,110					189			189
328	Edgewood	1921	285	*y*	6,205					6			6
329	Elgin, South	1917	1,985	*x*	18,615					107			107
330	Enfisco	1921	290	1,051,554	7,607					5			5
331	Fairfax	1925	220	*y*	23,725					16			16
332	Falls Dome	1920	380	*y*	16,790					19			19
333	Flat Rock	1906	7,485	*x*	259,150					579			579

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
287		41	Dolomite, U. Simpson, 2nd Wilcox	Ord								
288		39	2nd Wilcox	Ord	S		7,670	7,672	2			
289		38	Upper Simpson	Ord	y	y	y	y	y			
290		45	Simpson, 2nd Wilcox	Ord	S, D, L	Por				AF		
291		35	2nd Wilcox	Ord	S		6,738	6,766	28			
292		39	Simpson, Wilcox	Ord		Por				AF	Arbuckle	7,000
293		37	Red Fork	Pen	S		5,920		5			
294		35	Cleveland	Pen	S	y	4,796	4,808	12		2nd Wilcox	5,998
295		35	Hunton	Sil-Dev	L		6,004	6,095	91		2nd Wilcox	6,610
296		36	Trosper	Pen	S	Por	6,157	6,168	11	ML		
297		37	Various	Pen, Ord	S, L	Por		6,700	y			
298												
299												
300		33	Bartlesville, Burgess, Mississippian	Pen, Mis								
301		39	Burgess, Siliceous	Mis, Ord, Cam	S, L		2,500 2,750	2,525 2,765	25 15			
302	RP	33	Bartlesville, Burgess	Pen	S		1,400 1,450	1,465 1,600				
303		32	Bartlesville, Burgess	Pen	S							
304		34	Bartlesville, Mississippian	Pen, Mis	S, L							
305		34	Various	Pen, Mis	S, L							
306		36	Various	Pen, Mis, Ord, Cam								
307		33	Peru, Bartlesville, Mississippian, Arbuckle	Pen, Mis, Cam	S, L		1,110 1,550	y 1,725	y 75			
308		33	Bartlesville, Burgess	Pen	S							
309		34	Bartlesville	Pen	S							
310		33	Various	Pen			650	1,265				
311		35	Bartlesville, Mississippian	Pen, Mis	S, L							
312		34	Bartlesville, Burgess, Mississippian	Pen, Mis	S, L							
313		37	Various	Pen, Mis, Ord, Cam	S, L		1,500	2,620				
314		38	Simpson	Ord	S		3,064		15			
315		36	Wilcox, Arbuckle	Ord, Cam								
316		34	Layton, Peru, Oswego, Mississippian	Pen, Mis	S, L							
317		40	Bartlesville, Burgess, Mississippian	Pen, Mis	S, L							
318		37	Various	Pen, Mis	S, L							
319		34	Various	Pen, Mis	S, L							
320	RP	38	Layton, Burbank, Wilcox	Pen, Ord	S		2,700	2,850	60	ML	Granite	4,240
321	PM	38	Burbank, Skinner	Pen	S			2,850				
322		33	Bartlesville, Burgess	Pen	S							
323		39	Bartlesville, Burgess	Pen	S							
324		33	Various	Pen, Ord								
325		38	Bartlesville, Burgess	Pen	S							
326		33	Various	Pen	L, S		650	1,265				
327		36	Stray, Bartlesville, Mississippian	Pen, Mis	S, L		1,570 1,680 1,880	1,124 1,780 1,925	67 100 45			
328		35	Bartlesville, Burgess, Mississippian	Pen, Mis	S, L							
329		33	Ramsey, Pennsylvanian, Oswego	Pen								
330		36	Stray, Oswego, Mississippian	Pen, Mis	S, L							
331		38	Oswego, Burbank, Wilcox	Pen, Ord	S	20-25			y	ML		
332		36	Oswego, Bartlesville, Burgess	Pen								
333	RP	34	Bartlesville, Burgess	Pen	S		1,110 1,345	1,205 1,365	95 20		Wilcox	1,667

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
334	Flesher	1919	320	*x*	4,380					5			5
335	Foraker (Redrilled)	1920–42		*y*	4,380					1			1
336	Forty-five	1916	1,795	*x*	30,660		1			107			107
337	Frankfort	1920		*y*					Abandoned				
338	Gilliland	1919	770	*x*	15,330					13			13
339	Happy Hollow	1919	540	*x*	52,195					27			27
340	Hardy	1934	40	51,751	6,935					1			1
341	Hickory Creek	1914	2,220	*x*	37,960					156			156
342	South	1939	340	*x*	132,341					36			36
343	Hominy	1916	415	*x*	22,995					11			11
344	Hominy, East	1918	630	*x*	18,615					20			20
345	Hominy, South	1940	30	11,240	1,820					3			3
346	Hominy Falls	1919	1,385	*x*	28,105					52			52
347	Kasishke	1921	140	*y*	7,300					17			17
348	Kaw	1922	180	232,287	33,183					7			7
349	Landon	1919	145	*x*	2,920					9			9
350	Lee Dome	1926	80	*y*	6,570					5			5
351	Madalene	1920	520	*y*	22,995					37			37
352	East	1923	400	*y*	13,870					32			32
353	Manion	1927	460	897,524	24,634					31			31
354	North	1920	910	*y*	69,715					59			59
355	Myers	1919	260	*x*					Abandoned during 1942				
356	Naval Reserve	1933	3,290	17,869,849	947,905	254				233			233
357	Nelagoney (Redrilled)	1919–42		*x*	6,935	3	1		Abandoned	3			3
358	New England	1920	585	*y*	32,120					27			27
359	Ochelata, North	1910	1,560	*x*	47,815					86			86
360	Ohio-Osage	1932	195	*y*	1,825					24			24
361	Okesa	1904	1,210	*x*	3,650					10			10
362	Osage City	1904	3,805	*x*	284,700					216			216
363	East	1920	805	*y*	59,130					61			61
364	Osage-Hominy	1917	1,625	*x*	243,455					138			138
365	Page	1918	745	*x*	19,345					30			30
366	Pawhuska	1919	505	*x*	32,120					18			18
367	West	1919	180	*x*	4,015					6			6
368	Pearsonia	1919	180	*x*	109,500					21			21
369	Penn Creek	1922	160	*y*	7,665					2			2
370	Pershing	1918	5,595	*x*	103,660					255			255
371	Pettit	1923	285	*y*	25,550					15			15
372	Pioneer	1920	300	*y*	16,060					21			21
373	Pond Creek	1913	1,295	*x*	16,060					56			56
374	Prue	1926	475	*y*	7,300					11			11
375	Quapaw	1914	3,645	*x*	62,050					195			195
376	Ramona	1911	1,755	*x*	72,635					81			81
377	Skiatook	1911	715	*x*	14,965					27			27
378	Sunset	1919	295	*x*	1,825					10			10
379	Tidal-Osage	1918	1,975	*x*	72,270					104			104
380	Turkey Creek	1917		*x*					Abandoned				
381	West	1925		*y*					Abandoned during 1941				
382	Whitetail	1919	205	*x*	2,555					1			1

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
334		35	Bartlesville, Mississippian	Pen, Mis								
335												
336		34	Oswego, Skinner, Bartlesville	Pen								
337			Pennsylvanian, Oswego, Mississippian	Pen, Mis	S, L							
338		36	Various	Pen, Mis, Ord, Cam	S, L							
339		36	Oswego, Bartlesville, Burgess	Pen								
340		39	Layton	Pen	S							
341		35	Oswego, Bartlesville, Mississippian	Pen, Mis	S, L							
342		36	Wayside									
343		34	Various	Pen, Mis, Ord, Cam	S, L		2,625	2,685	50	A	Arbuckle	3,206
344		34	Bartlesville, Mississippian, Hominy, Arbuckle	Pen, Mis, Ord, Cam	S		2,160	2,210		A	Arbuckle	2,857
345		40	Oswego	Pen								
346		36	Various	Pen, Mis	S, L							
347		40	Burbank	Pen	S							
348		35	Prue, Skinner	Pen								
349		35	Peru, Oswego, Bartlesville	Pen								
350		36	Oswego, Bartlesville, Burgess	Pen								
351		35	Prue, Oswego, Bartlesville	Pen								
352		35	Bartlesville	Pen	S							
353		38	Layton, Oswego, Bartlesville, Burgess	Pen								
354		38	Bartlesville, Wilcox	Pen, Ord	S							
355		34	Layton, Burgess	Pen								
356		39	Burbank	Pen	S				y	y		
357												
358		34	Bartlesville, Burgess, Arbuckle	Pen, Ord, Cam								
359		34	Prue, Bartlesville	Pen	S							
360		37	Cleveland, Bartlesville	Pen	S							
361		34	Prue, Bartlesville, Mississippian	Pen, Mis	S, L							
362		37	Burbank, Burgess, Arbuckle	Pen, Ord, Cam	S, L							
363		37	Cleveland, Bartlesville	Pen	S		1,620 2,250	1,645 2,280	25 30		Mississippian	2,431
364		37	Layton, Oswego, Bartlesville, Burgess	Pen	S, L		y	y	y			
365		33	Various	Pen, Ord, Cam	S, L							
366		35	Bartlesville, Burgess, Burgen, Arbuckle	Ord								
367		36	Bartlesville, Burgess, Burgen, Arbuckle	Pen, Ord, Cam	S, L							
368		36	Layton, Oswego, Burgess, Mississippian	Pen, Mis	S, L							
369		35	Bartlesville, Mississippian	Pen, Mis	S, L							
370		35	Cleveland, Bartlesville	Pen	S		1,385 2,033	1,400 2,063	15 30	D		
371		36	Various	Pen, Ord, Cam	S, L		y	y	45	A	2nd Wilcox	
372		34	Various	Pen, Ord	S, L							
373		33	Various	Pen, Mis	S, L							
374		36	Prue, Bartlesville	Pen	S							
375		34	Oswego, Skinner, Bartlesville	Pen	S		1,720	1,780	60			
376		33	Big Lime, Bartlesville, Burgess	Pen	S, L							
377		34	Bartlesville, Burgess, Mississippian	Pen, Mis	S, L							
378		36	Bartlesville, Hominy, Arbuckle	Pen, Ord	S, L							
379		36	Burgess, Bartlesville	Pen	S							
380												
381		33	Pennsylvanian sand	Pen	S							
382		32	Stray, Bartlesville, Mississippian	Pen, Mis	S, L							

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift
383	Wildhorse	1912	4,670	x	247,105					398			398
384	North	1919	360	x	27,375					20			20
385	South	1923	205	y	13,140					11			11
386	West	1940	160	92,754	43,972					4			4
387	Woolaroc	1917	2,525	x	47,815					157			157
388	Wynona	1917	3,475	x	68,255					155			155
389	Miscellaneous		2,380	y	191,485					99			99
390	Aggregate for district of pools marked x or y			329,720,947									
391	Total Osage County		154,070	592,018,837	11,840,777					7,992			7,992
	SEMINOLE AREA												
392	Adams, *Hughes*	1935	320	1,576,105	254,468	10				10			10
393	Alabama, *Hughes*	1923	640	y	29,930					20			20
394	Buchner, *Hughes*	1924	140	y	9,855					1			1
395	Calvin, *Hughes*	1938	80	102,035	6,916	5				3			3
396	Fish, *Hughes*	1934	1,750	18,047,142	911,679					142			142
397	Fuhrman, *Hughes*	1925	395	1,803,454	6,469					8			8
398	Gilcrease, *Hughes*	1924	245	421,475	1,313					1			1
399	Holdenville, North, *Hughes*	1926	80	139,498	2,287					1			1
400	Holdenville, West, *Hughes*	1916–30	1,340	5,477,461	188,705		3			108			108
401	Jefferson, *Hughes*	1925		407,219	0				Abandoned				
402	Lamar, *Hughes*	1923		104,160	0				Abandoned				
403	Papoose, *Hughes*	1923	2,815	22,034,938	184,650	279				56			56
404	Spaulding, *Hughes*	1929	80	81,748	4,957					2			2
405	Wetumka, *Hughes*	1923	255	y	16,060					4			4
406	East	1938	80	170,508	73,995					5			5
407	South	1926	100	y	3,650					4			4
408	Yeager, *Hughes*	1925	345	1,926,470	33,580					6			6
409	North, *Hughes*	1936	100	152,781	21,203					6			6
410	Miscellaneous, *Hughes*		220	167,309	16,158					10			10
411	Bearden, Northwest, *Okfuskee*	1941	100	64,978	58,436					8			8
412	Castle, *Okfuskee*	1941	200	128,995	60,960	2				2			2
413	North, *Okfuskee*	1941	200	44,997	27,349	3				3			3
414	South, *Okfuskee*	1941	120	28,538	12,577	3				3			3
415	Cromwell, East, *Okfuskee*	1940	1,520	2,604,965	1,160,206	73	11			60			60
416	Cromwell, North, *Okfuskee*	1938	100	768,691	206,494					15			15
417	Dill, *Okfuskee*	1931	1,650	4,808,140	473,974	95	1			84			84
418	Olympic, *Okfuskee*	1934	3,860	11,882,739	496,118	348				324			324
419	Rusk, *Okfuskee*	1941	150	685,245	547,129	9	1			9			9
420	Asher, *Pottawatomie*	1929	430	3,661,822	36,387	70				5			5
421	West, *Pottawatomie*	1930	780	7,566,348	88,932					33			33
422	Avoca, *Pottawatomie*	1938	240	1,332,433	202,544	18				17			17
423	Brooksville, *Pottawatomie*	1942	440	195,518	195,518	8	8			8			8
424	Centerpoint, *Pottawatomie*	1942	200	46,448	46,448	4	4			4			4
425	Earlsboro, Northwest, *Pottawatomie*	1942	200	3,912	3,912	1	1			1			1
426	Earlsboro, West, *Pottawatomie*	1924–29	1,405	3,233,773	759,218					76			76
492	Gray, *Pottawatomie*	1932	575	4,686,997	331,420	35				26			26
427	Grisso, *Pottawatomie*	1934	210	370,628	18,096					3			3
428	Hotulke, West, *Pottawatomie*	1941–42	1,000	1,062,139	829,485					24			24
430	King, *Pottawatomie*	1939	100	132,749	11,208					3			3
431	West, *Pottawatomie*	1939	100	230,586	1,552					1			1
432	Macomb, *Pottawatomie*	1942	300	27,311	27,311	2	2			2			2
433	Maud, *Pottawatomie*	1928	1,980	12,265,837	191,733	158	2			59			59
434	South, *Pottawatomie*	1941	140	418,994	181,941	9				9			9
435	Prague, *Pottawatomie*	1940	220	811,308	252,376	18	1			17			17
436	Romulus, *Pottawatomie*	1940	450	1,237,842	324,510		2			20			20
437	Romulus, Townsite, *Pottawatomie*	1942	80	18,516	18,516	1	1			1			1
438	Sacred Heart, *Pottawatomie*	1939	140	306,213	34,969					8			8

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
383		35	Various	Pen, Ord	S, L		3,550	4,260				
384		35	Various	Pen, Ord	S, L							
385		35	Various	Pen								
386		38	Arbuckle	Ord, Cam								
387		34	Skinner, Bartlesville	Pen	S							
388		35	Various	Pen, Mis	S, L		1,600	2,281				
389		35										
390												
391												
392		40	Misener	Mis	S	Por			15	A	Wilcox	4,317
393		39	Various	Pen								
394		35	Booch, Cromwell	Pen	S		[y]	[y]	[y]			
395		36	Viola	Ord	L		[y]	[y]	[y]			
396		37	Various	Pen, Ord			[y]	[y]	[y]			
397		37	Gilcrease, Cromwell	Pen	S		[y]	[y]	[y]			
398		39	Gilcrease	Pen	S		[y]	[y]	[y]			
399		40	Cromwell	Pen	S		3,418	3,437	19			
400		37	Various	Pen, Ord	S							
401												
402		39										
403		36	Calvin, Gilcrease, Cromwell	Pen	S	Por			10	A	Wilcox	
404		35	Booch	Pen	S							
405		38	Various	Pen, Sil-Dev	S, L							
406		53	Hunton, 2nd Wilcox	Sil-Dev, Ord	S							
407		39	Gilcrease, Cromwell	Pen	S							
408		39	Various	Pen, Sil-Dev, Ord	S, L							
409		37	Cromwell, Hunton, 2nd Wilcox	Pen, Sil-Dev, Ord	S, L							
410		35	Booch, Cromwell	Pen	S							
411		36	Booch	Pen	S		2,954		20			
412		43	Booch, Hunton	Pen, Sil-Dev			3,950	3,960				
413		41	Cromwell	Pen			3,310	3,323	13			
414		43	Hunton	Sil-Dev			3,930	3,942	12			
415		36	Cromwell, Hunton, Wilcox	Pen, Sil-Dev, Ord								
416		36	Booch, Cromwell	Pen	S							
417		36	Senora, Cromwell, Hunton	Pen, Sil-Dev	S, L	Por						
418		34	Senora, Cromwell	Pen	S	Por	3,433	3,475	[y]			
419		38	Cromwell	Pen			3,691	3,710				
420		35	Booch	Pen								
421		39	Wanette, Viola	Ord	S, L		[y]	[y]	[y]			
422		43	Wanette				3,450					
423		39	Viola, 2nd Wilcox	Ord	S, L							
424		33	Hunton	Sil-Dev	L		4,759		28			
425		40	Dolomite	Ord	S		5,593		20			
426		37	Earlsboro	Pen	S		3,875		20			
427		38	Hunton	Sil-Dev	L		[y]	[y]	[y]			
428		40	Wanette, Hunton, Simpson	Sil-Dev, Ord			2,500	3,475	25	A	Wilcox	3,500
429		36	Hunton, Simpson	Sil-Dev, Ord	L						Wilcox	4,860
430		38	Viola, Wilcox, Hunton	Ord, Sil-Dev	S, L							
431		41	Hunton, Viola	Sil-Dev, Ord	L		4,374	4,416	42			
432		41	Hunton	Sil-Dev	L		4,281	4,306	25			
433		34	Hunton	Sil-Dev	L		4,700		75			
434		38	Misener, Hunton, Simpson	Mis, Sil-Dev, Ord	S, L	Por	4,130	4,140	10	A	Wilcox	4,330
435		40	Simpson	Ord	D		4,320	4,325	5			
436		34	Senora	Pen								
437		38	Hunton	Sil-Dev								
438		28	Hunton	Sil-Dev	L		4,880		20			

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
			Oil	To End of 1942	During 1942	Completed to End of 1942	During 1942		End of 1942			Number of Wells	
							Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
439	Shawnee, *Pottawatomie*	1934	1,090	3,132,702	299,506					48			48
440	East, *Pottawatomie*	1937		65,567	0		Abandoned during 1941						
441	North, *Pottawatomie*	1937	120	392,114	110,951					3			3
442	Shawnee, Northeast, *Pottawatomie*	1942	90	9,842	9,842	1	1			1		1	
443	St. Louis, *Pottawatomie*	1927	19,905	159,460,841	5,027,563	1,223	9			803			803
444	East, *Pottawatomie*	1941	110	179,421	87,080	8	1			8			8
445	North, *Pottawatomie*	1941	760	844,726	514,220	32	13			32			32
446	Tecumseh, *Pottawatomie*	1937	40	157,534	18,427	1				1			1
447	East, *Pottawatomie*	1941	280	399,165	189,857	13	4			9			9
448	Tecumseh Lake, *Pottawatomie*	1941	150	941,555	459,021	12				11			11
449	Miscellaneous, *Pottawatomie*		110	*y*	6,192					5			5
450	Allen (deep), *Seminole*	1927	4,030	52,690,070	1,366,560	475				294			294
451	Bethel, *Seminole*	1925	620	1,874,102	55,224					35			35
452	North, *Seminole*	1936	455	4,075,467	366,688	32				26			26
453	Northeast, *Seminole*	1941	20	6,666	3,110	2				2			2
454	West, *Seminole*	1941	150	199,593	156,605	5				5			5
455	Bowlegs, *Seminole*	1926	4,270	121,018,608	1,894,185	364				208			208
456	Carr City, *Seminole*	1927	1,885	31,452,080	668,796	122	1			78			78
457	Cromwell, *Seminole*	1923	5,465	58,081,069	952,551	502	1			236			236
458	South, *Seminole*	1937	100	524,906	60,605	8				6			6
459	Dill, South, *Seminole*	1941	100	139,335	73,561	4				4			4
460	Dora, *Seminole*	1935	1,260	5,004,506	338,221					104			104
461	Earlsboro, *Seminole*	1926–42	5,235	126,592,658	1,117,825	499	2			171			171
462	East, *Seminole*	1929	2,105	39,237,248	536,051	189	2			78			78
463	North, *Seminole*	1936	665	6,212,287	1,092,053	36				36			36
464	South, *Seminole*	1930	430	9,149,299	306,438	39	3			26			26
465	Fish, West, *Seminole*	1941	20	14,742	6,489	1				1			1
466	Grayson, *Seminole*	1935	530	2,061,886	202,983					33			33
467	Grayson, North, *Seminole*	1942	80	3,552	3,552	1	1			1			1
468	Hazel, *Seminole*	1938	330	479,846	56,153	21				17			17
469	Jackson, *Seminole*	1925	735	764,412	25,792					10			10
470	Keokuk, *Seminole*	1933	2,585	12,600,244	1,012,599	107				96			96
471	Konawa, *Seminole*	1929	1,695	15,530,882	317,867	124				91			91
472	East, *Seminole*	1936	225	212,829	8,874					6			6
473	South, *Seminole*	1938	560	1,240,943	261,777		4			48			48
474	West, *Seminole*	1938	220	642,584	82,796	16				15			15
475	Little River, *Seminole*	1927	4,625	113,595,056	1,875,516	602	1			217			217
476	East, *Seminole*	1928	910	16,900,063	181,993					62			62
477	North, *Seminole*	1941	220	296,518	156,449	5				5			5
478	Southeast, *Seminole*	1940	40	22,784	11,604	2				2			2
479	West, *Seminole*	1938	270	937,786	119,311					13			13
480	Mission, *Seminole*	1928	1,570	25,859,161	356,886	122				61			61
481	Rosanna, *Seminole*	1924	505	*y*	89,425					20			20
482	Sancho, *Seminole*	1929	120	347,819	14,195					6			6
483	Sasakwa, *Seminole*	1927	1,145	11,172,514	327,039	111	5			60			60
484	Sasakwa Townsite, *Seminole*	1933	175	2,428,705	93,306					8			8
485	Searight, *Seminole*	1926	2,110	34,595,314	336,915	144				55			55
486	East, *Seminole*	1939	80	179,600	11,037					4			4
487	North, *Seminole*	1934	381	3,688,367	189,734	19				13			13
488	Seminole City, *Seminole*	1926	4,635	130,830,328	1,990,647	403	2			194			194
489	Seminole: East, *Seminole*	1926	1,905	8,810,768	283,966	132				86			86

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
439		32	Earlsboro	Pen	S		2,862	2,883	21			
440		34	Earlsboro	Pen	S	Por			y	y		
441		31	Wilcox	Ord	S		4,839	4,844	5			
442		36	Simpson	Ord			4,853	4,886	33			
443		33	Wilcox	Ord	S		4,835		18			
444		38	Various	Pen, Sil-Dev, Ord	S, L	Por	y	y	y	y		
445		37	Wilcox	Ord			4,111	4,119	8			
446		38	Hunton	Sil-Dev	L		3,863	3,879	16			
447		37	Simpson	Ord	D		5,125	5,238	113			
448		35	Viola, Wilcox	Ord			4,582 4,835	4,620 4,838	38 3			
449		38	1st Wilcox	Ord			5,234	5,244	10			
450		36	Earlsboro	Pen	S							
451		36	Various	Mis, Sil-Dev, Ord	S, L		2,500	4,250				
452		36	Booch, Gilcrease, Cromwell	Pen	S					ML		
453		40	Cromwell	Pen	S	Por			20	A	Cromwell	
454			Cromwell	Pen								
455		39	Cromwell	Pen			3,450	3,451				
456		40	Various	Pen, Sil-Dev, Ord	S, L	Por			30	A		
457		40	Misener, Hunton, Wilcox	Mis, Sil-Dev, Ord	S, L	Por	4,180	4,205		A	Wilcox	4,210
458		37	Various	Pen, Ord	S	Por		3,400		AF	Wilcox	4,226
459		37	Wapanucka-Cromwell, Wilcox	Pen, Ord	S		4,176	4,189	13			
460		40	Hunton	Sil-Dev			4,128	4,150	22			
461		35	Boggy, Calvin	Pen	S		2,947	2,959				
462		38	Earlsboro, Hunton, Wilcox & Simp. Dolo.	Pen, Sil-Dev, Ord	S, L		y	y	y			
463		39	Calvin, Hunton, Wilcox	Pen, Sil-Dev, Ord	S, L		y	4,250	y			
464		41	Hunton, Wilcox	Sil-Dev, Ord	S, L					A	Wilcox	4,680
465		39	Calvin, Hunton, Wilcox	Pen, Sil-Dev, Ord	S, L	Por	4,200	4,225	25	A	Wilcox	4,225
466		36	Booch	Pen			3,168	3,192	24			
467		40	Simpson	Ord		y	4,030	4,050	20	y	y	y
468		33	Hunton	Sil-Dev	L		4,160		10			
469		36	Thurman, Boggy	Pen	S		2,991	3,003	12	y		
470		38	Booch	Pen	S		y	y	y			
471		40	Misener, Hunton, Wilcox	Mis, Sil-Dev, Ord	S, L	y			y	y	Wilcox	4,483
472		36	Earlsboro, Cromwell, Simpson	Pen, Ord	S		y	y				
473		39	Earlsboro	Pen	S		y	y	y			
474		37	Hunton, Viola, Wilcox	Sil-Dev, Ord	S, L							
475		36	Boggy, Calvin	Pen	S		2,697	2,714	17			
476		38	Various	Pen, Ord	S	Por	y	4,100	y	y		
477		36	Various	Pen, Ord	S	y	y	y	y	y		
478		41	Hunton, Dolomite, Wilcox	Sil-Dev, Ord			4,282	4,289	7			
479		38	Senora	Pen								
480		39	Wilcox	Ord	S		4,378	4,380	2			
481		39	Hunton, Wilcox	Sil-Dev, Ord	S, L		y	4,300	y			
482		38	Booch	Pen	S		3,034	3,054	20			
483		37	Gilcrease, Cromwell	Pen	S							
484		36	Various	Pen, Ord	S, L		2,793	4,187				
485		37	Wilcox	Ord	S	Por	4,047	4,050	3	y		
486		38	Hunton, Wilcox	Sil-Dev, Ord	S, L	Por	4,120	4,325	y	y		
487		39	Cromwell	Pen	S		3,775	3,791	16	y		
488		32	Wilcox	Ord	S	y	4,596	y	y	y		
489		39	Various	Pen, Mis, Sil-Dev, Ord	S, L	Por				y	y	

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
			Oil	To End of 1942	During 1942	Completed to End of 1942	During 1942		End of 1942			Number of Wells	
							Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
490	North, *Seminole*	1940	100	82,419	33,114					7			7
491	West, *Seminole*	1935	385	13,791,012	579,088	40				33			33
492	Swan, *Seminole*	1938	10	15,703	1,939					1			1
493	Sylvian, *Seminole*	1941–42	80	37,882	33,371	4	3			4			4
494	Sylvian, Northeast, *Seminole*	1942	40	15,215	15,215	2	2			2			2
495	Transco, *Seminole*	1926		104,143	0				Abandoned				
496	Traugh: Deep, *Seminole*	1937	140	934,685	75,555	16				14			14
497	Shallow, *Seminole*	1937	300	917,053	74,044	27				24			24
498	Tyrola, *Seminole*	1937	100	87,093	12,081	5				3			3
499	Wetley, *Seminole*	1927	675	544,100	31,108					15			15
500	Wewoka, *Seminole*	1923	2,015	34,352,666	335,070	239	5			82			82
501	East, *Seminole*	1927	365	1,542,802	41,975	30				8			8
502	North, *Seminole*	1940	100	225,993	92,668	5	1			5			5
503	Northeast, *Seminole*	1941	200	614,449	39,055	5	2			5			5
504	Wewoka Townsite, *Seminole*	1924	345	6,112,312	123,370	40				27			27
505	Wofford, *Seminole*	1935	60	668,142	15,637					3			3
506	Miscellaneous, *Seminole*		200	185,045	61,969					21			21
507	Aggregate for district of pools marked *x* or *y*			4,064,013									
508	Total Seminole Area		106,106	1,180,591,756	33,658,490					4,820			
	SOUTHEASTERN OKLAHOMA												
509	Ardmore, *Carter*	1942	80	12,657	12,657					2		2	
510	Brock, *Carter*	1922	765	3,622,757	96,925					127			127
511	Caddo, *Carter*	1939	20	42,530	8,762					1			1
512	Caddo, (Deep), *Carter*	1942	20	55,414	55,414					1		1	
513	Centrahoma, *Coal*	1937	80	107,905	19,807	3				3			3
514	Clarita, *Coal*	1937	40	76,939	10,892	4				3			3
515	Miscellaneous, *Coal*	1940	10	1,413	93					1			1
516	Pauls Valley, *Garvin*	1942	600	803,368	803,368	15	15			14		*y*	*y*
517	Miscellaneous, *Garvin*	1936		15,364	0					1			1
518	Citra, *Hughes*	1937		6,130	0	1			Abandoned				
519	Miscellaneous, *Love*	1937	40	4,197	0					1			1
520	Byars, *McClain*	1939	280	463,012	131,447		2			6			6
521	Aylesworth, *Marshall*	1942	40	5,245	5,245					1			1
522	Cumberland, *Marshall*	1940	1,880	5,532,552	2,743,265	60	17			60		*y*	*y*
523	Enos, *Marshall*	1933	265	163,200	13,505					23			23
524	Isom Springs, *Marshall*	1931	380	199,242	28,105		7			61			61
525	Kingston, *Marshall*	1932	115	17,502	1,095					9			9
526	Madill, *Marshall*	1925	275	1,125,500	14,235					73			73
527	Miscellaneous, *Marshall*	1932		*y*	0					1			1
528	Ada, East, *Pontotoc*	1928	325	281,285	21,170					13			13
529	Allen (shallow), *Pontotoc*	1913	2,530	8,834,468	119,720					185			185
530	Bebee, *Pontotoc*	1923	2,925	13,105,286	1,113,980					217			217
531	East, *Pontotoc*	1930	215	429,422	37,308					20			20
532	Conservation, *Pontotoc*	1927	285	530,368	21,900					13			13
533	Fitts, *Pontotoc*	1933	5,955	96,113,659	3,020,164	989				680			680
534	North, *Pontotoc*	1934	150	562,796	27,098					15			15
535	South, *Pontotoc*	1937	205	489,432	65,518					22			22
536	West, *Pontotoc*	1937	175	468,787	58,060		1			12			12
537	Francis, *Pontotoc*	1918	60	*x*	0					1			1
538	West, *Pontotoc*	1917	135	*x*	5,110					7			7
539	Jesse, *Pontotoc*	1935	1,235	5,617,355	661,604		1			57			57
540	Oakman, *Pontotoc*	1935	80	28,652	2,797					5			5
541	Roper, *Pontotoc*	1942	160	19,516	19,516	3	3			3			3
542	Steedman, *Pontotoc*	1920	50	23,310	0					1			1
543	North, *Pontotoc*	1928	305	1,733,027	77,745					14			14
544	Miscellaneous, *Pontotoc*		60	8,648	0					2			2

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
490		38	Cromwell, Hunton, Wilcox	Pen, Sil-Dev, Ord	S, L			3,514				
491		31	Senora	Pen								
492		42	Calvin, Wilcox	Pen, Ord	S	Por	4,085	4,115	30	A	Wilcox	4,150
493		36	Thurman		S		2,671	2,691	20			
494		34	1st Wilcox, Cromwell	Ord, Pen			4,366	4,384	18			
495		37	Cromwell	Pen	S		3,652		10			
496		36	Calvin, Senora	Pen			2,159	2,174	15			
497		36	Simpson, Wilcox	Ord	S			*y*	*y*			
498		33	Earlsboro	Pen	S		2,347	2,360	13			
499		37	Hunton	Sil-Dev	L		3,317	*y*	*y*			
500		35	Hunton	Sil-Dev	L		2,420	2,585	165			
501		37	Cromwell, Hunton, Wilcox	Pen, Sil-Dev, Ord	S, L	Por						
502		38	Hunton, Wilcox	Sil-Dev, Ord	S, L		4,214	*y*	*y*			
503		41	Wilcox	Ord								
504		36	Misener, Hunton	Miss, Sil-Dev			3,940	3,995				
505		38	Various	Pen, Sil-Dev, Ord	S, L							
506		40	Boggy, Wilcox	Pen, Ord	S		*y*	*y*	*y*			
507		38	Senora, Calvin, Hunton	Pen, Sil-Dev	S, L							
508												
509												
510		39	Springer	Pen	S		3,302		40			
511		32	Ordivician, Arbuckle	Ord, Cam	S	Por		2,100		AF	Ord Lime	3,000
512		35	Woodford	Mis	S		4,170	4,324	154			
513		41	Bromide	Ord	S		5,412		15			
514		38	McAlester sand, Viola	Pen, Ord	S, L		5,970	6,235	265			
515		39	Atoka		S		790	836	46			
516			Cromwell	Pen			1,835	1,900				
517		42	Bromide	Ord.	S		3,950		50			
518												
519		34	Bromide, McLish	Ord	S		5,755	5,994	*y*			
520		34										
521		37	Layton, Viola	Pen, Ord	L		3,485	3,623	138			
522			Tulip Creek	Ord	S		3,110		10			
523		37	Bromide, McLish	Ord								
524		26	Preston, Arbuckle	Ord, Cam								
525		26	Stray sand		S		537	540	3			
526		26	Cretaceous, Trinity									
527		40	Bilbo, Arbuckle	Ord, Cam	S		402					
528												
529		27	Boggy, Senora	Pen	S		1,790	1,795	5			
530		30	Allen									
531		36	Boggy, Hunton, Viola	Pen, Sil-Dev, Ord								
532		35	Senora, Hunton, Viola, Simpson	Pen, Sil-Dev, Ord	S, L							
533		30	Boggy, Hunton	Pen, Sil-Dev							Wilcox	3,062
534		39	Various	Pen, Sil-Dev, Ord	S, L							
535		32	McAlester, Gilcrease	Pen	S		1,767	*y*	*y*			
536		35	Gilcrease, Hunton, Viola	Pen, Sil-Dev, Ord	S, L							
537		39	Cromwell	Pen	S		3,021	3,110	89			
538		26	Allen, Senora	Pen			1,200	2,000				
539		27	Allen, Senora	Pen								
540		40	Hunton, McLish	Sil-Dev, Ord	L, S							
541		29	Boggy	Pen	S		1,160	1,169	9			
542		38	Viola	Ord	L		2,531		41			
543		31	Boggy	Pen								
544		31	Boggy	Pen								

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
							During 1942		End of 1942			Number of Wells	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift
545	Aggregate for district of pools marked *x* or *y*....			236,272									
546	Total Southeastern Oklahoma..................		19,740	140,737,210	9,196,505					1,655		*y*	
	SOUTHWESTERN OKLAHOMA												
547	Sayre, *Beckham*..............	1923		304,519	0				Abandoned				
548	Apache, *Caddo*..............	1941	1,292	1,923,808	1,748,933	27	18			26		*y*	*y*
549	Binger, *Caddo*..............	1934	80	86,749	5,827	1				1			1
550	Cement, *Caddo*..............	1917	4,505	26,158,531	3,248,910	487	9			358			358
551	Miscellaneous, *Caddo*.........			6,565	0				Abandoned				
552	Ed Cox, *Carter*..............	1925	770	808,759	81,395		1			42			42
553	Fox, *Carter*..................	1917–35	1,100	14,893,894	299,300					94			94
554	Graham, *Carter*..............	1917	2,990	26,750,857	332,880					255			255
555	Healdton, *Carter*............	1913	7,550	193,375,411	2,825,844	2,362				1,881			1,881
556	Hewitt, *Carter*..............	1919	4,530	95,837,710	3,327,199	1,101	7			907			907
557	Sholem Alechem, *Carter*.... ..	1923	4,760	38,718,699	842,235	401				306			306
558	Tatums, *Carter*..............	1927	2,660	16,743,978	563,363	247				208			208
559	Tussy, *Carter*................	1933	1,485	5,439,199	1,063,500		6			103			103
560	Wheeler, *Carter*.............	1916	755	*x*	10,220					72			72
561	Wildcat Jim, *Carter*.........	1914	1,235	*x*	381,790					85			85
562	Miscellaneous, *Carter*.........		40	1,798	725					4			4
563	Hanbury, *Comanche*..........	1920	280	*y*	1,095					5			5
564	Lawton, *Comanche*...........	1915	960	*y*	2,555					95			95
565	Walters, *Cotton*..............	1917	3,790	25,717,489	282,510					223			223
566	Robberson, *Garvin*...........	1921	2,410	15,489,527	310,492	328				166			166
567	Knox, *Grady*.................	1924	1,990	15,551,021	549,814	269				176			176
568	Miscellaneous, *Grady*.........	1923		*y*	0				Abandoned				
569	Altus, *Jackson*..............	1934	1,740	1,774,474	230,056		1			113			113
570	Tipton, *Jackson*.............	1935	880	1,840,636	165,498		1			57			57
571	Oscar, *Jefferson*.............	1924	685	10,632,558	431,795		2			191			191
572	Seay, *Jefferson*..............	1924	325	544,145	14,600					40			40
573	Spring, *Jefferson*............	1924	265	*y*	183,960		2			38			38
574	Hobart, *Kiowa*...............	1939	500	1,350,063	385,966					24			24
575	Stockton, *Love*..............	1937	40	57,125	8,037					1			1
576	Comanche, *Stephens*..........	1918	925	1,055,495	157,680					146			146
577	Cruce, *Stephens*.............	1926	100	*y*	6,570					3			3
578	Doyle, *Stephens*........... ...	1921–37	315	*y*	190,530		2			34			34
579	West, *Stephens*...........	1939	100	126,541	33,101					3			3
580	Duncan: North, *Stephens*.....	1920	1,260	4,356,088	129,210					81			81
581	West, *Stephens*...........	1919	910	6,000,272	102,930					71			71
582	Empire, *Stephens*............	1920	2,630	*y*	782,925		6			267			267
583	Loco, *Stephens*..............	1915	575	1,573,401	52,925					61			61
584	West, *Stephens*...........	1941	100	20,301	20,301	16	10			10			10
585	Milroy: Deep, *Stephens*	1937-39	235	536,462	110,595					1		1	
586	Shallow, *Stephens*	1916	800	3,458,351	103,660					142			142
587	Palacine, *Stephens*...........	1929	120	181,795	16,425					3			3
588	Rainola, *Stephens*.......... .	1921	150	*y*	30,660					18			18
589	Velma, *Stephens*............	1917	2,910	6,557,511	435,080		19			652			652
590	Velma, North, *Stephens*.......	1942	800	4,645	4,645					1			1
591	Woolsey, *Stephens*...........	1922	170	*y*	20,075		6			19			19
592	Woolsey, South, *Stephens*.....	1942	60	40,539	40,539					7			7
593	Miscellaneous, *Stephens*.......		140	54,257	12,141					5			5
594	Frederick, *Tillman*...........	1937	80	31,534	4,652					2			2
595	West, *Tillman*..........	1937–39	300	2,740,190	595,662					30			30
596	Red River Bed, *Tillman*......	1920	500	*y*	99,280					82			82
597	Aggregate for district of pools marked *x* or *y*....			40,233,273									
598	Total Southwestern Oklahoma..................		60,797	570,477,626	20,248,085					7,109			
599	Total Oklahoma.............		788,241	5,067,012,857	137,792,355					52,443			

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
545			Hunton	Sil-Dev	L							
546												
547												
548		34	Deese	Pen	S	Por		*y*	*y*			
549		39	Simpson	Ord			3,395	3,430				
550		38	Deese	Pen								
551		34	Various	Per, Pen	S		1,900	1,600				
552			Miscel, Caddo									
553		22	Pontotoc, Deese	Pen			1,250	2,910	30			
554		31	Fox sand, Simpson, Oil Creek	Pen, Ord	S		2,200	2,500		A		
555		31	Deese	Pen	S	28–30				A	Dornicks Hills	5,180
556		31	Various	Pen, Ord	S, L		920	3,500		AF	Arbuckle	*x*
557		34	Hewitt, Viola	Pen, Ord	S	15–20	920	2,700		AF	Arbuckle	*x*
558		29	Hoxbar, Deese	Pen	S	30	1,890	4,000		A		
559		27	Deese, Arbuckle	Pen, Ord	S	30			60			
560		23	Deese	Pen	S	Por			*y*	A		
561		20	Pontotoc	Pen	S	*y*				A		
562		24	Pontotoc, Deese	Pen			1,552	2,890				
563		20										
564		38	Various	Pen	Gw, S		1.640	2,100				
565		30										
566		34	Cisco, Hoxbar				2,100	2,400				
567		23	Pontotoc, Simpson	Pen, Ord	S, L	*y*	1,200	1,900		A		
568		35	Pontotoc	Pen	S	15–20	1,700	2,200	15	AF		8,963
569			Pontotoc	Pen								
570		41	Granite wash	Pen	Gw	Por			30	D		
571		40	Canyon, Arbuckle	Ord	L		*y*	*y*	*y*			
572		33	Glenn	Pen	S		1,180	1,610	25			
573		35	Cisco, Hoxbar				1,100					
574		35	Hoxbar				2,095	2,101	6			
575		35	Pontotoc, Conglomerate	Pen	L		1,091	1,107	16			
576		36	Unidentified		S		6,893	6,927	34			
577		34	Stray, Wilson, Pace		S		1,400	1,800				
578		30	Upper Penn.	Pen	S		800	1,900				
579		30	Permian, Hoxbar, Deese				1,100	1,250				
580		42	Deese	Pen	S		5,578	5,614	36			
581		36	Thomas				1,700	2,300				
582		33	Brown, Blaydes				1,700	2,300				
583		39	Various				1,600	2,300				
584		23	Pontotoc, Deese	Pen	S		850	1,550				
585		34	Sandy Lime				1,113	1,135				
586		42	Hunton, Oil Creek	Sil-Dev			7,554	7,625	71			
587		26	Pontotoc	Pen								
588		36	Pennsylvanian, Arbuckle	Pen, Ord								
589		36	Smith, Brown	Pen								
590		26	Permian, Glenn, Bromide	Per, Pen, Ord	S							
591		43	Bromide	Ord	S		7,000		100			
592		32	Permian, Glenn	Per, Pen								
593			Arbuckle	Cam-Ord	L		1,783		22			
594		36	Deese	Pen	S							
595		39	Canyon, Strawn	Ord	L, S		3,081					
596		37					4,215	4,218	3			
597		39	Cisco				1,540	1,700	19			
598												
599												

TABLE 2.—*Summary of Drilling Operations in Oklahoma*

Important Wildcats Drilled in 1942

County	Location	Total Depth, Ft.	Surface Formation	Deepest Formation Tested	Drilled by	Initial Production per Day	Choke or Beam, Fraction of Inch	Pressure, Lb. per Sq. In.		Remarks
	Sec.-Tp.-Rge.					Oil, U. S. Bbl.		Cas-ing	Tub-ing	
Carter	24- 5 S - 1 E	3,302	Pennsylvanian	Springer	Lloyd Noble	349	⅛	800	150	Ardmore
Garvin	31- 4 N- 1 E	3,906	Quaternary	Simpson-Bromide	Pure	2,382	1 ck.			Pauls Valley
Logan	7-16 N- 2 W	5,759	Permian-Pa.	Wilcox and dolo.	Sunray et al.	840	1½	450	200	Guthrie Townsite
Marshall	13- 6 S - 6 E	3,690	Cretaceous	Simpson	H. F. Potts	104				PB 3,260 ft.; (Aylesworth)
Noble	4-20 N- 2 W	5,397	Permian	2nd Wilcox	Danciger	480				Lucien, NE.
Noble	9-22 N- 2 E	4,765	Permian-Pa.	2nd Wilcox	Deep Rock	1,268	¼ ck.			PB 4,552 ft.; Liberty
Pawnee	25-23 N- 3 E	3,891	Permian-Pa.	Wilcox	Alma Oil	2,528				East Watchorn
Pottawatomie	4- 8 N- 3 E	5,465	Permian	2nd Wilcox	Cities Service	344	¾ ck.			PB 5,083ft.(Hunton-Brooksville)
Pottawatomie	1- 9 N- 2 E	5,866	Permian	Wilcox	C. W. Sharp	172				PB-Simp-Dolo. (Centerpoint)
Alfalfa	12-24 N-11 W	7,300	Permian	2nd Wilcox	Olson et al.					Dry and abandoned
Atoka	2- 3 S -10 E	6,561	Cretaceous	Wapanucka ls.	C. C. Logan et al.					Dry and abandoned
Caddo	20- 5 N-11 W	5,235	Permian	Arbuckle	Texas Co.					Dry and abandoned
Caddo	14-10 N-13 W	8,000	Permian	Penn.	Amerada					Dry and abandoned
Caddo	11- 8 N-12 W	10,231	Perm-Quat.	Penn.	Amerada					Dry and abandoned
Carter	24- 4 S - 2 W	7,500	Cretaceous	Penn.	Carter					Dry and abandoned
Cimarron	35- 2 N- 8 ECM	6,168	Cretaceous	Arbuckle	Gulf					Dry and abandoned
Cimarron	27- 6 N- 5 ECM	4,250	Cretaceous	Granite wash	Placid oil					Dry and abandoned
Cleveland	33- 6 N- 1 E	6,568	Permian	Wilcox	F. C. Hall et al.					Dry and abandoned
Cleveland	6- 8 N- 1 E	6,822	Permian	2nd Wilcox	Phillips					Dry and abandoned
Comanche	6- 2 N- 9 W	4,766	Permian	Granite wash	Sinclair Prairie					PB 977 ft. for gas
Comanche	5- 3 N-10 W	8,078	Permian	Ordovician	Texas Company					Dry and abandoned
Comanche	25- 4 N-11 W	3,493	Permian	Simpson	Texas Company					Dry and abandoned
Comanche	20- 4 N-10 W	4,360	Permian	Penn.	Texas Company					Dry and abandoned
Garvin	29- 3 N- 1 E	5,003	Permian	Arbuckle	H. Culver et al.					Dry and abandoned
Grady	25- 3 N- 7 W	5,011	Permian	Granite wash	Roark & Hooker					Dry and abandoned
Harmon	25- 1 N-25 W	7,523	Permian	Strawn	Gulf					Dry and abandoned
Harmon	24- 5 N-26 W	3,510	Permian	Granite wash	Jordan Pet.					Dry and abandoned
Harmon	36- 1 S -24 W	7,504	Permian	Penn.	Lloyd Noble					Dry and abandoned
Hughes	18- 5 N-10 E	4,622	Pennsylvanian	Cromwell	Phillips					Dry and abandoned
Hughes	17- 7 N-11 E	5,524	Pennsylvanian	2nd Wilcox	Phillips-Cont.					Dry and abandoned
Hughes	31- 7 N-11 E	4,672	Pennsylvanian	Cromwell	Phillips					Dry and abandoned
Hughes	21- 8 N-11 E	3,733	Pennsylvanian	Cromwell	Phillips					Dry and abandoned (OWDD)
Jackson	20- 1 N-20 W	4,286	Permian	Arbuckle	Burnham					Dry and abandoned
Jackson	32- 2 N-23 W	7,503	Blaine-Permian	Bend ls.	Lloyd Noble					Dry and abandoned
Jackson	18- 3 N-20 W	3,284	Permian	Arbuckle	W. J. Moran					Dry and abandoned
Jackson	20- 3 N-20 W	4,022	Permian	Simpson	Rhinehart-Donoven					Dry and abandoned
Jefferson	9- 4 S - 6 W	5,902	Permian	2nd Wilcox	Carter					Dry and abandoned (OWDD)
Kay	4-25 N- 2 W	4,781	Quaternary	Wilcox	Helmerich & Payne					Dry and abandoned
Kay	19-25 N- 1 W	4,380	Permian-Pa.	Miss.	Helmerich & Payne					Dry and abandoned
Kay	27-28 N- 2 W	4,694	Permian-Pa.	2nd Wilcox	McKnab et al.					Dry and abandoned
Kay	4-28 N- 4 E	3,714	Permian-Pa.	Arbuckle	Skelly					Dry and abandoned

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1942

County	Location	Total Depth, Ft.	Surface Formation	Deepest Formation Tested	Drilled by	Initial Production per Day	Choke or Beam, Fraction of Inch	Pressure, Lb. per Sq. In.		Remarks
	Sec.-Tp.-Rge.					Oil, U S.		Cas-ing	Tub-ing	
Kingfisher	11-19 N- 7 W	8,225	Quaternary	2nd Wilcox	Union of California					Dry and abandoned
Lincoln	24-13 N- 4 E	5,125	Permian-Pa.	2nd Wilcox	B. F. Murray et al.					Dry and abandoned
Lincoln	18-14 N- 3 W	6,760	Permian	2nd Wilcox	Continental					Dry and abandoned
Logan	11-15 N- 4 W	6,747	Permian	2nd Wilcox	Cities Service					Dry and abandoned
Logan	5-17 N- 2 W	5,849	Permian-Pa.	2nd Wilcox	Continental et al.					Dry and abandoned
Logan	24-18 N- 1 W	5,398	Permian-Pa.	2nd Wilcox	Lewis Prod.					Dry and abandoned
Love	12- 7 S - 2 W	7,467	Cretaceous	Penn.	W. F. Turner					Dry and abandoned
Marshall	4- 6 S - 6 E	3,794	Cretaceous	2nd Wilcox	C. Marshall					Dry and abandoned
Noble	8-24 N- 3 E	4,241	Permian-Pa.	2nd Wilcox	Mason et al.					Dry and abandoned
Noble	13-24 N- 3 E	4,151	Quaternary	Wilcox	O. M. Mason et al.					Dry and abandoned
Okfuskee	30-12 N- 7 E	4,556	Penn.	2nd Wilcox	Mid-Continent					Dry and abandoned
Oklahoma	33-11 N- 1 E	6,338	Permian-Pa.	2nd Wilcox	E. Kubat et al.					Dry and abandoned
Oklahoma	35-12 N- 1 E	6,143	Permian-Pa.	2nd Wilcox	Mid-Continent					Dry and abandoned
Osage	29-21 N-10 E	2,606	Penn.	Arbuckle	Norbla et al.					Dry and abandoned
Osage	10-23 N- 7 E	2,675	Permian-Pa.	Miss. ls.	Cities Service					Dry and abandoned
Osage	29-25 N- 8 W	7,691	Permian	2nd Wilcox	Champlin					Dry and abandoned
Pawnee	30-23 N- 3 E	4,249	Permian-Pa.	2nd Wilcox	McBride					Dry and abandoned
Payne	9-17 N- 2 E	4,882	Quaternary	Wilcox	Superior-Olsen					Dry and abandoned
Payne	33-19 N- 1 W	5,441	Permian-Pa.	2nd Wilcox	Summitt Drilling					Dry and abandoned
Payne	9-19 N- 3 E	4,482	Permian-Pa.	2nd Wilcox	T. N. Berry					Dry and abandoned
Payne	19-20 N- 4 E	4,385	Permian-Pa.	Wilcox	Coralena					Dry and abandoned
Pontotoc	19- 2 N- 6 E	2,630	Simpson	Caney	Stanolind					Dry and abandoned
Pottowatomie	36- 9 N- 2 E	5,670	Permian	2nd Wilcox	Stanolind					Dry and abandoned
Pottowatomie	23- 9 N- 3 E	5,575	Permian	Dolomite	Ohio Oil Co.					Dry and abandoned
Pottowatomie	4- 9 N- 4 E	5,162	Penn.	2nd Wilcox	Stanolind-Amerada					Dry and abandoned
Pottowatomie	10-10 N- 3 E	5,742	Permian	Wilcox	Stanolind					Dry and abandoned
Pottowatomie	34-10 N- 3 E	5,431	Permian-Pa.	2nd Wilcox	Jordan & Atlantic					Dry and abandoned
Pottowatomie	7-11 N- 7 E	4,900	Permian-Pa.	2nd Wilcox	Mid-Continent					Dry and abandoned
Stephens	17- 1 N- 8 W	5,112	Permian	Granite wash	L. Sikes					Dry and abandoned
Stephens	14- 1 N- 4 W	4,003	Permian	Penn.	Kingery Prod.					Dry and abandoned
Tillman	28- 2 S -15 W	4,510	Permian	Arbuckle	Anderson-Prichard					Dry and abandoned

	In Proven Fields	Wildcats
Number of wells drilling, Dec. 1942	143	45
Number oil wells completed 1942	509	44
Number gas wells completed 1942	89	13
Number dry holes completed 1942	292	263

Seven developed areas saw the discovery of production in new horizons. These were the Bromide sand in the Caddo pool, Carter County; the Simpson dolomite in the Earlsboro pool, Seminole County; the Hunton lime in West Hotulke, Pottawatomie County; the Wilcox sand in Keokuk, Seminole County; the Hunton lime in the North Okemah pool, Okfuskee County; the Cromwell sand in Sylvian, Seminole County; and the Bartlesville sand in the South Wilzetta pool, Lincoln County. No new secondary-recovery projects were inaugurated during 1942. However, extensions were made to existing water-flood and gas-repressuring areas. Virtually all of this activity was confined to Rogers, Wagoner, and Nowata Counties in the northeastern shallow areas and to the Burbank and South Burbank pools in Osage County.

Demand

A strong crude market obtained throughout the year. During the latter part of 1942 many refiners were indeed hard-pressed for crude, and with crude stocks at a dangerously low level, some plants were struggling to maintain normal operations.

Most Important Development in Pools Discovered Prior to 1942

Crescent.—Completions in the Crescent pool totaled 15. Of these, 14 were oil wells with an average initial of 252 bbl., and one was a dry hole. At the end of the year, 45 wells producing from the Wilcox and Layton formations averaged 2800 bbl. daily. The daily average for the entire year was 2010 barrels.

East Cromwell.—In the East Cromwell pool in 1942 nine oil wells were completed with a combined initial production of 1711 bbl.; two gas wells with a total of 52,164,000 cu. ft. initial, and one dry hole. One recompleted oil well produced 210 bbl. initial and one reconditioned well was abandoned. Production averaged 3179 bbl. daily, with 60 wells producing at the close of the year, averaging 2100 bbl. daily. Production is from the Cromwell, Hunton, and Wilcox zones.

Oklahoma City.—Outstanding in the state's petroleum history is the prolific Oklahoma City pool, a 1928 discovery. During 1942 this pool produced 26,310,000 bbl., or 19.1 per cent of the state total. The pool's cumulative recovery to Jan. 1, 1943, of 582,452,000 bbl. represents 11.5 per cent of the entire state's production. At the close of the year, production in the Oklahoma City pool was averaging 60,000 bbl. daily from 870 wells. While production in this pool has come from several producing zones, 84 per cent of the current production and 74 per cent of the pool's total recovery is from the Wilcox sand. Eighteen oil wells were completed in 1942 with an average initial production of 312 bbl. Seven dry holes were drilled and 14 wells reconditioned, with an average of 224 bbl. initial. Production averaged 72,080 bbl. daily during the year against an average of 87,620 bbl. during 1941.

Apache.—Development in the Apache pool saw 18 oil wells completed for an average initial of 5925 bbl., 3 dry holes, and 11 reconditioned oil wells having a combined initial production of 67,784 bbl. This pool produced 1,749,000 bbl. during 1942, making a total recovery to Jan. 1, 1943, of 1,923,800 bbl. At the end of the year, the pool was averaging 6300 bbl. daily from 26 wells. Production is from Bromide sands at approximately 3400 feet.

Cumberland.—The Cumberland pool shared in the state's 1942 development to the extent of 16 oil wells completed, with an average initial production of 1678 bbl., one gas well, 5,160,000 cu. ft., two dry holes, and three reconditioned oil wells, with a combined initial of 2580 bbl. Production averaged 7516 bbl. daily against an average of 6473 bbl. for the preceding year. Production to Jan. 1, 1943, amounted to 5,532,600 bbl. At the end of the year, the pool was producing an average of 8000 bbl. daily from 60 wells.

Oil and Gas Development in Northern and Central Pennsylvania during 1942

By Arthur C. Simmons,* Member A.I.M.E.

The area that produces Pennsylvania grade, which includes New York, Pennsylvania, West Virginia and a part of Ohio, increased its production in 1942 about 1,580,000 bbl. over that attained in 1941. Such an increase is substantial for this area, and measured in terms of increased output of lubricants, for which the crude is particularly suitable, it represents a needed and worth-while addition to the lubricant resources of the United States.

The year 1942 was a difficult operating period for most of the petroleum-producing areas in the United States, but the Appalachian region, owing principally to its location, type of operations, and crude value, suffered less from war influences than other areas. The state of Pennsylvania produced 17,823,870 bbl. of crude oil, which is approximately 63 per cent of the total production of Pennsylvania grade in the entire area.

PRODUCTION

Bradford Field

The Bradford field, which produces almost wholly by water-flooding methods, increased its production nearly 4000 bbl. per day over 1941 despite a very slight reduction in total number of wells completed. Well completions in the Bradford field (in both New York and Pennsylvania) include both producing oil wells and water-intake wells. About half of the well completions are producing oil wells and the remaining half are water-intake or injection wells. About 10 per cent of the total well completions of the Bradford field were in Cattaraugus County, New York. No segregation of well completions is available, so that precise statistics cannot be given for New York and Pennsylvania.

Table 1.—*Production of Pennsylvania Grade Oil in* 1942
Barrels

Month	Bradford Field		Allegany Area	Southern Pennsylvania	Ohio	West Virginia	Total
	Pennsylsylvania	New York					
January	38,490	3,660	10,818	10,064	4,161	9,484	76,677
February	38,523	3,648	10,667	9,198	4,321	9,500	75,857
March	38,881	3,691	10,827	10,214	4,322	10,000	77,935
April	41,340	3,811	11,255	11,594	4,634	10,433	83,067
May	38,985	3,654	10,833	10,302	4,157	9,581	77,512
June	41,423	3,826	11,549	10,768	3,134	12,000	82,700
July	39,015	3,843	11,374	10,284	4,645	9,871	79,032
August	39,017	3,712	10,802	9,824	4,354	9,839	77,548
September	39,254	3,769	11,336	10,308	4,567	10,333	79,567
October	38,464	3,758	10,867	10,234	4,677	10,355	78,355
November	36,395	3,539	10,464	9,068	4,467	8,900	72,833
December	36,424	3,697	10,752	8,643	4,000	8,968	72,387
Daily average	38,850	3,717	10,969	10,038	4,432	9,792	77,786

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* Geologist and Petroleum Engineer, Bradford, Pa.

TABLE 2.—*Oil Production in the State of Pennsylvania*

	Wells Completed, Bradford Field[a]	Change	Oil Production Bradford Field, Bbl.[b]	Change	Oil Production Central and Southern Pennsylvania, Bbl.	Change	Oil Production State of Pennsylvania, Bbl.	Change
Total:								
1937	4,112		15,076,909		4,108,100		19,185,109	
1938	2,148	−1,964	13,417,102	−1,659,807	4,008,923	− 99,177	17,426,025	−1,758,984
1939	2,114	− 34	12,899,104	− 517,998	4,438,035	+429,112	17,337,139	− 88,886
1940	3,004	+ 890	12,748,279	− 150,825	4,604,763	+166,728	17,353,042	+ 15,903[c]
1941	3,207	+ 203	12,729,900	− 18,379	4,104,100	−500,663	16,834,000	− 519,042
1942	3,113	− 94	14,160,000	+1,430,100	3,663,870	−440,230	17,823,870	+ 989,870
Daily average:								
1937			41,300		11,255		52,555	
1938			36,759	− 4,541	10,983	− 272	47,742	− 4,813
1939			35,340	− 1,419	12,159	+ 1,176	47,499	− 243
1940			34,831	− 509	12,581	+ 422	47,412	− 87[c]
1941			34,876	+ 45	11,244	− 1,337	46,120	− 1,292
1942			38,795	+ 3,919	10,038	− 1,206	48,833	+ 2,713

[a] Includes oil and water-intake wells and New York state part of Bradford field.
[b] Pennsylvania production only.
[c] Variance between total production and daily average occasioned by 365-day year in 1939 and 366-day year in 1940.

Development technique within the water-flood area was similar to that of previous years although the practices in connection with water-flooding are gradually improved from year to year.

The Bradford field had produced approximately 200,000,000 bbl. of oil by water-flooding methods to Jan. 1, 1943, and it is estimated that the remaining recoverable reserves will approximate 100,000,000 barrels.

Central and Southern Pennsylvania

The oil production in central and southern Pennsylvania declined 440,000 bbl. from 1941. The production from Music Mountain, which is the only flush field in the state, is largely included in production statistics of central and southern Pennsylvania. Production at Music Mountain (Table 3) declined from an average of 2865 bbl. per day in 1941 to 1412 bbl. per day in 1942. This represents a total decline of 530,000 bbl. attributable to the Music Mountain field alone and consequently there was an increase in the remaining portion of central and southern Pennsylvania. This increase was brought about by an improvement in price conditions as the price cut initiated by the Office of Price Administration in August 1941 was restored to the Pennsylvania grade area in March 1942.

TABLE 3.—*Production from Music Mountain Field,* 1942

BARRELS

January	1,775	August	1,300
February	1,660	September	1,220
March	1,540	October	1,200
April	1,755	November	1,150
May	1,560	December	1,100
June	1,350		
July	1,355	Daily average for year	1,412

CRUDE-OIL PRICES

Only one change occurred in crude-oil prices throughout the year; that is, 25¢ per barrel was restored by the Office of Price Administration from a cut in August 1941. The average price in the Bradford field for the entire year was $2.94 per barrel, as compared with $2.56 in 1941. In central and southern Pennsylvania the average price was $2.85 as compared with 1941 average of $2.47. In southwestern Pennsylvania there was an average price of $2.59, as compared with a 1941 average of $2.21.

SUMMARY

Despite the restrictive influences of wartime conditions with respect to materials, labor, increasing production costs, and other items, Pennsylvania increased its production in 1942 over 1941. It appears doubtful whether such an increase can be maintained, for without additional price increases production of Pennsylvania grade, both within and without the state of Pennsylvania, will undoubtedly decrease in 1943.

There was more interest in shallow, outlying, wildcat locations than in former years. With the apparent inevitable decline in Pennsylvania production there could occur a sharp increase in wildcat exploration, but development depends largely on the creation and maintenance of proper prices.

Additional areas were tested for waterflooding methods, with indications that this may be successful in some of the other oil pools of Pennsylvania.

Oil and Gas Developments in Southwestern Pennsylvania during 1942

By John T. Galey*

The restrictions placed on drilling by the Federal Government, which caused a severe curtailment in activity at the beginning of the year, were relaxed somewhat so as to permit the drilling of one shallow† gas well per 40 acres. New wells numbering 574‡ were drilled for a combined depth of nearly 1,500,000 ft., and of this number 131 were dry holes with a footage of slightly over 375,000. Inside locations account for the majority of these totals and the increasing demand for natural gas would normally have increased the number considerably, but many of the independent operators chose to ask for fewer exceptions to Order M-68 of the Office of Production Management, and consequently to curtail the number of wells drilled.

Initial open flow of natural gas developed from all operations§ is over 230 million cu. ft. Nearly 191 million cu. ft. of this volume resulted from the 410 new gas wells drilled to horizons above the Lower Devonian, and the footage drilled in these wells accounts for approximately 93 per cent of the total.

SHALLOW DEVELOPMENT

Oil.—Thirty oil wells, with a total initial production of slightly over 152 bbl. and a footage of 50,000, were drilled during the

TABLE 1.—*New Wells Drilled for Gas and Oil in Southwestern Pennsylvania during* 1942[a]

County	Gas Wells	Footage	Initial Open Flow, M Cu. Ft.	Oil Wells	Footage	Initial Production, Bbl.	Dry Holes	Dry Hole, Footage	Total Wells	Total Footage
Allegheny	14	32,228	16,430	1	1,590	8.00	8	19,720	23	53.538
Armstrong	105	286,552	13,825	1	1,391	0.5	14	37,012	120	324,955
Beaver	0	0	0	1	1,193	0.25	3	4.255	4	5,448
Butler	18	38,346	1,825	15	21,822	18.00	14	25,312	47	85,480
Fayette	28	68,835	20,824	0	0	0	14	36,078	42	104,913
Greene	78	223,347	58,617	3	4,472	85.00	13	35,931	94	263,750
Indiana	29	77,965	19,770	0	0	0	19	63,199	48	141,164
Lawrence	2	1,378	684	0	0	0	0	0	2	1,378
Washington	41	87,766	12,830	9	19,605	41.00	19	48,367	69	155,738
Westmoreland	34	106,261	9,926	0	0	0	6	18,213	40	124,474
Armbrust pool	61	128,100	36,000	0	0	0	12	25,200	73	153.300
Total	410	1,050,778	190,731	30	50,073	152.75	122	313,287	562	1,414,138
LOWER DEVONIAN DRILLING										
Summit Pool	3	21,241	22,825	0	0	0	4	30,981	7	52.222
Oriskany Wildcats	0	0	0	0	0	0	5	31,643	5	31,643
Total	413	1,072,019	213,556	30	50,073	152.75	131	375,911	574	1,498,003

[a] Excluding wells drilled deeper.

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* Oil and Gas Operator, Pittsburgh, Pa.

† As deep as the Lower Devonian.

‡ This represents a greater total than last year, but it is believed that the number of wells drilled is almost the same, and that the information of a year ago was not complete.

§ Including deepening wells previously drilled.

year. The relatively low price of crude oil ($2.65 per bbl.), which has prevailed since the 25-cent increase on March 26, together with the 40-acre spacing regulation, accounts for this diminished activity.

The outstanding developments of the year occurred in Greene County, where two new pools apparently have been discovered. One of these pools, in Perry township, which is nearly three miles from oil production, found 15 bbl. initial in the 5th sand (U. Dev.) at 3198 to 3200 ft. The second pool was found in Monongahela township, where a well being drilled for Big Injun sand (Miss.) gas on the Ritz farm encountered 40 bbl. initial production in the Dunkard (Penn.) at 620 ft. A second well drilled approximately on the spacing allowed found 30 bbl. in the same sand. These wells are about 2½ miles east of the Willow Tree pool, which has produced from the Dunkard (Penn.) sand for several decades.

Butler County again leads in the number of producers completed even though the total is two less than a year ago. However, better wells were found in Allegheny, Greene and Washington Counties. A well drilled into the 3rd sand (U. Dev.) at a depth of 1590 ft. in Marshall township, Allegheny County, found an 8-bbl. initial, which is considerably above the average. Four of the Washington County wells found production in the 5th sand (U. Dev.) in proven areas and three others had small production in the Big Injun sand (Miss.) in an area where heretofore there has been little activity.

Gas.—The two areas of most active development are the Armbrust, Hempfield township, Westmoreland County, 5th sand (U. Dev.) pool, and the German-Menallen-Nicholson township, Fayette County-Monogahela township, Greene County, Big Injun sand (Miss.) field. A dozen wells had initial open flow of from 0.9 to 13 million cu. ft. in the latter field and two wells of 2.5 million cu. ft. capacity in the 50-ft. sand (U. Dev.) and 5th sand (U. Dev.). However, the Armbrust pool, which now has a proven area of nearly 2100 acres, more than three times that of a year ago, had many more completions than this. The wells here, which averaged 0.6 million cu. ft., are the kind that are considered capable of greater ultimate yield than those in the first area mentioned.

In Allegheny County the old producing area in Forward township had three completions with large open flow. Two of these in the Bayard sand (U. Dev.) had 8.72 and 1.2 million cu. ft. and the third, in the Big Injun sand (Miss.), 4.5 million cubic feet.

Armstrong County again leads in number of completions, the majority of which were drilled to the Bradford sand (U. Dev.), in which relatively small production was found. The only large well made 3 million cu. ft. from the Gas sand (Miss.). The discovery in Valley township 5th sand (U. Dev.) of a year ago was not developed into a pool.

In an attempt to extend last year's Gas sand (Miss.) discovery in Cranberry township, Butler County, two dry holes were drilled. However, several miles east of this area a well drilled into the Boulder sand (U. Dev.) at 2100 ft., on the Steed farm, found 0.5 million cu. ft., which was the largest open flow in the county.

Outside Monongahela township the Big Injun sand (Miss.) had five good wells in Greene County. They were found in Center, Gilmore, Jackson and Washington townships and ranged in open flow from 0.7 to 2.25 million cu. ft. Center township also had several wells of nearly 0.5 million cu. ft. in the Bayard sand (U. Dev.), and one of nearly 5 million cu. ft. in the 50-ft. sand (U. Dev.).

Probably the largest well ever drilled in Indiana County, and one of the largest in the area during the year, was found in Young township on the Rochester and Pittsburgh Coal Company's land. The initial open flow was 13 million cu. ft. and the producing horizon is the Boulder sand, which was found at a depth of 1967 ft. Production from this well, as in most of those with large volume, has declined considerably. This well was an offset drilled to one on the S. J. Armstrong farm, which had 1.9 million cu. ft. in the same sand.

Only one new well in Washington County had large open flow and this was encountered in the Big Injun sand of Somerset township. The initial volume was 2.25 million cubic feet.

Westmoreland County had three notable wells. One of these, drilled in Bell township, had 1.5 million cu. ft. in the Tiona sand (U. Dev.) at 2594 ft., and the other, in North Huntington township, had 2.4 million cu. ft. with considerable salt water, in what is probably the 30-ft. sand (U. Dev.) at 2390 ft. The third well, drilled in Bell township, had slightly over 0.8 million cu. ft. in the Freeport sand (Penn.) at 457 ft., and is said to have held up remarkably well considering the depth at which the gas was found.

DEEP-SAND DEVELOPMENT

Summit Pool

The results of drilling in the Summit pool are more encouraging than they appear, for while one well, which was running low, was abandoned before the Tully limestone (M. Dev.) was reached, the two wells that were high on structure found 11.7 and 11 million, respectively, in the Onondaga (L. Dev.). The former open flow is the largest yet encountered in the chert and the well has a 55-ft. lower subsea elevation than the highest well on the structure. A third well found small production on the downthrown side of one of the faults and the remaining three wells all found salt water.

TABLE 2.—*Status of Summit (Fayette County) Pool*
NEW WELLS AS OF DECEMBER 31, 1942

Township	Well	Elevation, Ft.	Top Tully, Ft.	Top Onondaga, Ft.	Top Oriskany, Ft.	Total Depth, Ft.	Result	Remarks
South Union..	Piedmont No. 4	2,491	6,756	8,089[a] 8,116[c]	Not reached	8,211	SW.[b] 8,195 to 8,204 and 8,211	First well to find SW.[b] in pool. Downthrown side of fault.
Wharton.....	Piedmont No. 6	2,514	6,023	6,496[a] 6,543[c]	Not reached	6,577	11,700 M cu. ft. gas 6,554, 6,557, 6,558 and 6,564. 1500 lb. R.P.[d] 26 hr.	Largest volume to date in chert.
South Union..	Carothers No. 1	2,567				7,092	Abd. 3-12-42	Did not reach Tully. Downthrown side of fault.
Wharton.....	Kirby No. 1	2,690	6,984	7,547[a] 7,547[c]	7,752	7,943	125 M cu. ft. gas at 7,583. 1,660 lb. R.P. 33 hr.	Downthrown side of fault.
Wharton.....	Heyn No. 4[e]	2,531	6,005	6,470[a] 6,504[c]	6,646	6,721	11,000 M cu. ft. gas, 6,519, 6,528 and 6,533	Oriskany dry. Highest well on structure to date
Georges......	Barton No. 2	2,557	7,292	7,795[a] 7,810[b]	Not reached	7,868	SW.[b] 7,868. 6000 ft. in 24 hr.	Downthrown side of fault.
Georges......	Barton No. 3	2,451	6,506	7,600[a] 7,631[b]	7,795	7,810	SW.[b] 7,810, 1 bailer per 2 ½ hr.	Downthrown side of fault.
Wharton.....	Indian Creek No. 2	2,674						Drilling 5,443 ft.
Georges......	Walters No. 1	2,583						Drilling 6,480 ft.
Total......						52,222	22,825 M cu. ft.	

[a] Onondaga limestone.
[b] Salt water.
[c] Onondaga chert.
[d] Rock pressure.
[e] Included in 1941 report although not completed until early 1942.

Two of these were drilled in close proximity to the well drilled a year ago, which extended the pool several miles to the southwest. They crossed over to the east side of the fault and one found salt water in the Oriskany (L. Dev.) while the other found it in the Onondaga. The third well, which encountered salt water in the latter horizon, was also on the downthrown side of the fault in the main part of the pool.

Three wells were deepened during the year, one of which found no additional gas, a second 0.5 million cu. ft., and the third 13 million cu. ft. in the Helderberg limestone (L. Dev.). The third well is the second to produce from this horizon in the pool; one well was drilled into it last year but has yielded little gas.

Thus a total initial open flow of nearly 35 million cu. ft. of new gas was developed during the year and the initial volume of production per foot of hole drilled, including dry holes, is considerably higher than the average for shallow drilling.

The structure in this pool is narrow and highly complicated by faulting. Seismograph work has not been successful, as reflections cannot be obtained in the areas where the rocks are shattered by faulting, and it is in these areas that control is most necessary.

The majority of the wells show a decided tendency to deviate from the vertical, which causes considerable difficulty in drilling, and this difficulty becomes more acute as the fault is approached. One of the operators in the pool has considered an attempt to control the deviation from the vertical by use of oriented whipstocks but as yet this method of completing a well to the desired spot on the subsurface structure has not been tried. In surveying the wells drilled, it has been found that the tendency to lead off is noticeable in the top part of the hole. Some suggestion has been made that several spudder holes be drilled to a depth of approximately 500 ft. at and around a

TABLE 3.—*Status of Wildcat Wells, Testing Lower Devonian or Deeper Horizons, as of December 31, 1942.*

County	Township	Farm Name	Elevation, Ft.	Top Tully, Ft.	Top Onondaga, Ft.	Top Oriskany, Ft.	Total Depth, Ft.	Result	Remarks
Beaver	Center	Koehler Hrs. No. 1[a]	1,066		5,145[b]	5,312	5,345	½ bailer SW.[d] per hr., 5,319 to 5,330 ft.	
Greene	Richhill	Workman No. 1 (Alley)	1,246		6,776[b]	7,016	7,118	1½ bailer SW. per hr., 7,034 ft.	
Lawrence	Slippery Rock	Miller and Myers No. 1	1,207	4,340	4,506[b]	4,674	4,740	Show gas and amber oil, 4,685 to 4,686 ft.	
Lawrence	Slippery Rock	Hill No. 1	1,197		4,510[b]	4,664	6,360	Show gas and little SW., 4,666 to 4,668 ft.	
Westmoreland	Derry	Giffin No. 1	2,352						Location
Westmoreland	Ligonier	Beck No. 1	2,784						Drilling 7,270 ft.
Westmoreland	South Huntington	Jacobs Creek No. 1	964	6,720	7,317[b] 7,348[b]	7,902	8,080	Dry	Temperature at 8,080, 211°F.
Total							31,643		

[a] Included in 1941 report although not completed until early 1942.
[b] Onondaga limestone.
[c] Onondaga chert.
[d] Salt water.

proposed location, that these holes be surveyed and the deep well be drilled on the location shown by the survey to be most nearly vertical.

WILDCAT DRILLING

The five wildcat wells completed were disappointing in result. Two of these, in Slippery Rock township, Lawrence County, were 24 ft. higher on the Oriskany sand than a previously drilled well in the same area, which had 70,000 cu. ft. of gas followed by salt water, but found only a show of gas. The second of the two wells drilled here during the year tested the Lockport dolomite (Sil.) and found it barren. Unfortunately, the Medina was not reached. The fact that porosity exists in the Oriskany sand in the southwest corner of Pennsylvania was demonstrated by the well in Richhill township, Greene County, as 1½ bailers of salt water per hour was found in that horizon.

The top of the Onondaga ran regionally high in the deep test in South Huntington township, Westmoreland County, and it appeared that chances favored the finding of production in the Oriskany. However, the great thickening of the Onondaga horizon put the latter regionally low and not even a show was found. Some interesting speculation has been aroused over this abnormal Onondaga thickness. The author, in a study of the interval from the top of the Onondaga to the base of the Lockport dolomite, has observed that a depositional basin, the axis of which extends into southwestern Pennsylvania in a southeasterly direction from the saddle in the Cincinnati arch in southwestern Ontario, was in existence at least from early Silurian to early Devonian time. Wells in this basin in northeastern Ohio usually find an abnormal Onondaga thickness and there is some indication that this may be so where the basin projects into southwestern Pennsylvania.

MATERIAL

In the southwestern portion of the area an average of slightly more than 47 tons of casing was used per well. This figure is based on an average completion depth of 2950 ft. As the over-all average shallow drilling depth is about 2520 ft., and the weight of casing used in the northern part of the area is considerably less than that in the south, a fair estimate is probably less than 40 tons of casing per well over the entire area.

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Oil and Gas Developments in the Rocky Mountain Region in 1942

By C. E. Shoenfelt,* Member A.I.M.E.

Wildcat drilling in the Rocky Mountain region did not suffer as large a decline in 1942 as was anticipated. The drilling program laid out by the Government at the beginning of the year stressed wildcatting operations and called for reduction of drilling in proved fields. The increased wildcatting campaign did not yield a great many new discoveries, nor important extensions to old fields.

Several interesting wildcat wells were drilled in Colorado in 1942 but no new fields were discovered. The Wilson Creek field was extended and about 400 acres added to its reserves.

In Montana two new oil fields and two small gas fields were discovered. The developments in the marketing situation had improved, however, making the prospects especially bright for 1943, as will be shown presently in the section on Montana in this report.

In New Mexico eight wells were completed, which constituted discoveries of either oil or gas but none of these was of major proportions.

In Wyoming one new oil field and one new gas field were discovered, and one old oil field and one old gas field were extended. Most important was the discovery of prolific oil producers in deeper sands in three old oil fields, of which one at least, Elk Basin, probably is of major proportions.

Government Action

On Dec. 26, 1942, President Roosevelt signed the O'Mahoney bill, calling for a flat 12.5 per cent royalty on lands in the public domain. It is expected that the enactment of this bill will encourage wildcatting in the public land states.

Opportunity for a full discussion of the problems of reserves and production was afforded at the hearings conducted on the O'Mahoney bill by the minerals subcommittee of the Senate Committee on Public Lands and the statements submitted at these hearings last fall placed the situation, its causes and the logical remedy, clearly on record.

It was established at the hearings that for several years the volume of oil discovered per wildcat well drilled has steadily declined; new fields discovered have not been of major proportions; drilling costs have advanced rapidly; a sharp decline in exploratory drilling took place in 1942, while the proportion of dry holes increased; the inescapable conclusion is that to find new reserves the search for oil must be intensified and much more wildcat drilling must be done. To ensure an adequate drilling campaign, the Petroleum Industry War Council, the Interstate Compact Commission and other representative oil organizations have voiced by resolution their opinion that an upward revision of crude prices is necessary to provide an incentive to the prospector to undertake the hazards of wildcat drilling, since statistics prove that only one in five or six wells drilled results in actual production.

Former Price Administrator Henderson rejected the recommendations for price increases and declared himself unalterably opposed to a general price advance, on the ground that such advances would contribute to inflation. Now that Mr. Hender-

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* Geologist, Petroleum Information, Denver, Colorado.

TABLE 1.—*Oil and Gas Production in Rocky Mountain District*

COLORADO

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Production		Number of Wells	Producing Formation			
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	Character[b]
				OIL, Bbl.						
1	Berthoud, *Larimer*	1925	510	3,097	63,429	1	Hygiene	2,920	20	S
2	Boulder, *Boulder*	1902	400	4,777	659,454	9	Pierre	2,000		H
3	Florence, *Fremont*	1862	9,000	49,165	13,782,037	106	Pierre	2,200		H
4	Ft. Collins, *Larimer*	1923	400	29,145	2,261,192	8	Muddy-Dakota Sundance	4,535 5,063	25 139	S S
5	Greasewood, *Weld*	1930	200	5,485	476,279	1	Muddy-Dakota	6,645	35	S
6	Hamilton, *Moffat*	1923	400	121,791	5,918,847	11	Sundance	3,860	20	S
7	Hiawatha, *Moffat*	1929	640	187,999	335,231	8	Wasatch	Sand lenses		
8	Iles, *Moffat*	1924	600	537,396	9,611,245	30	Sundance	3,295	20	S
9	Powder Wash, *Moffat*	1936	80	37,038	77,190	2	Wasatch	Sand lenses		
10	Price, *Archuleta*	1934	200	439,860	1,629,291	9	Dakota	1,120	20	S
11	Rangely, *Rio Blanco*	1919	320	307,084	1,277,296	18	Mancos	600+		H
12	Tow Creek, *Routt*	1924	200	47,289	1,784,936	9	Mancos	2,600		H
13	Walden,[1] *Jackson*	1927	320	0	85,366	2	Muddy-Dakota	5,110	90	S
14	Wellington, *Larimer*	1924	1,000	80,792	5,001,938	11	Muddy-Dakota	4,480	20	S
15	Wilson Creek, *Rio Blanco*	1938	2,300	533,688	1,404,958	11	Morrison	6,550	125	S
				GAS, Millions Cu. Ft.						
16	Berthoud, *Larimer*	1925	320	424	7,697	1	Hygiene	2,920	20	S
17	Garcia, *Las Animas*	1927	640	699	1,050	16	Benton	1,600		H
18	Hiawatha, *Moffat*	1928	3,180	37,997	300,412	13	Wasatch	Sand lenses		
19	Model,[2] *Las Animas*	1929	4,380	0	645	8	Santa Rosa (?)	960	50	S
20	Powder Wash, *Moffat*	1936	400	11,288	16,061	6	Wasatch	Sand lenses		
21	Thornburg, *Rio Blanco*	1925	350	1,675	6,347	3	Dakota	2,200	30	S

MONTANA

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Wells	Producing Formation			
				In 1942	Cumulative		Name	Age[c]	Top producing Zone, Ft.	Bottom, Ft.
22	Border, *Toole*	1930	450	11,208	1,096,640	9	Yanalta	CreL	2,470	2,500
23	Cat Creek, *Petroleum*	1920	1,600	265,669	15,273,551	118	Cat Creek	Cre	1,200	1,440
24	Cedar Creek, *Fallon*	1936	80	0	17,588	1	Madison	Mis	6,750	6,800
25	Cut Bank, *Glacier*	1932	38,000	5,512,755	31,530,763	699	Cut Bank	Jur	2,800	2,835
26	Dry Creek, *Carbon*	1930	200	108,901	1,960,778	7	Cloverly	CreL	5,500	5,525
27	Elk Basin, *Carbon*	1916	140	16,044	1,037,482	22	Frontier	CreU	1,000	1,200
28	Frannie, *Carbon*	1940	40	21,026	52,820	2	Tensleep	Pen	2,770	3,530
29	Kevin-Sunburst, *Toole*	1922	45,000	2,540,243	42,173,984	1,102	Ellis-Madison Contact	Jur-Mis	1,400	1,405
30	Lake Basin, *Stillwater*	1924	300	16,957	479,730	2	Eagle-Frontier-Dakota	CreU	1,200	1,320
31	Pondera, *Teton*	1927	1,600	261,664	6,206,828	152	Madison	Mis	1,975	1,990
32	Sweetgrass Hills, *Toole*	1929	500	5,401	113,776	11	Upper Ellis	Jur	1,400	1,420

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[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Wells produce large quantities of CO_2 gas with the oil shut in.

[2] Gas contains 7.9 per cent helium, balance nitrogen and CO_2.

TABLE I.—(*Continued*)

UTAH

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Gas Prod. Million Cu. Ft.		Number of Wells	Producing Formation			
				In 1942	Cumulative		Name	To Top, Ft.	Thickness, Ft.	Character
33	Ashley Valley,[3] *Uinta*	1926	240	0	22,015	0				
34	Cisco,[4] *Grand*	1925	2,000	0	3,128	0				
35	Clay Basin, *Daggett*	1928	2,800	43,844	1,479,969	8				
36	Farnham,[5] *Carbon*	1924	600	1,489	91,208	1				

WYOMING

	Field, *County*	Year of Discovery	Area Proved, Area	Total Oil Production, Bbl.		Number of Wells	Producing Formation			
				In 1942	Cumulative		Name	Age[e]	Top producing Zone, Ft.	Bottom, Ft.
37	Badger Basin, *Park*	1931	300	42,423	470,387	4	Frontier	CreU	8,250	8,500
38	Big Medicine Bow, *Carbon*	1935	800	244,120	4,039,188	10	Sundance	Jur	5,200	5,430
39	Big Muddy, *Converse*	1915	2,000	398,314	27,415,101	135	Wall Cr. & Dakota	CreU	3,260	3,400
40	Black Mountain, *Hot Springs*	1925	300	18,014	286,395	6	Embar-Tensleep	Per-Pen	2,900	3,350
41	Byron, *Big Horn*	1906	2,950	1,683,673	7,509,183	19	Embar-Tensleep	Per-Pen	5,400	5,530
42	Circle Ridge, *Fremont*			59,805	59,805	11	Tensleep	Pen	600	650
43	Cody (See Shoshone), *Park*									
44	Cole Creek, *Natrona*	1938	900	375,489	877,734	18	Shannon	CreU	4,550	4,650
45	Dallas-Derby, *Fremont*	1883	350	148,016	3,285,254	40	Embar-Tensleep	Per-Pen	750	900
46	Dutton Creek, *Carbon*	1927	150	18,484	306,230	3	Muddy	CreU	4,850	4,900
47	Elk Basin—Light, *Park*	1915	580	179,470	11,578,519	144	Frontier	CreU	1,000	1,200
48	Elk Basin—Heavy, *Park*	1942	3,000	8,456	8,456	1	Tensleep	Pen	4,488	4,530
49	Ferris, *Carbon*	1918	200	15,501	560,521	12	Mowry-Dakota	CreU	1,600	1,650
50	Frannie, *Park*	1928	500	1,163,783	6,766,113	22	Tensleep	Pen	2,770	3,530
51	Garland, *Big Horn*	1930	2,000	504,410	5,206,227	18	Embar-Tensleep	Per-Pen	3,900	4,000
52	Gooseberry, *Park*		500	13,155	13,155	1	Embar-Tensleep	Per-Pen	5,669	6,049
53	Grass Creek, *Hot Springs*	1914	2,000	1,525,393	31,210,536	330	Frontier	CreU	800	1,200
54	Graybull, *Big Horn*	1907	640	0	346,730	3	Graybull	CreU	1,000	1,050
55	Hamilton, *Hot Springs*	1913	2,000	426,724	5,983,157	33	Embar-Tensleep	Per-Pen	2,700	3,332
56	Hidden Dome, *Washakie*	1933	50	39,955	378,545	14	Frontier	CreU	1,500	1,515
57	Hudson, *Fremont*	1914	340	99,101	2,319,677	17	Embar-Tensleep	Per-Pen	1,300	1,485
58	Iron Creek, *Natrona*	1922	120	3,956	28,280	3	Dakota	CreU	650	820
59	LaBarge, *Sublette*	1923	950	739,367	8,024,036	135	Wasatch	Eoc	650	1,000
60	Lance Creek, *Niobrara*	1918	15,000	8,605,384	49,871,154	190	Leo Zone, Minnelusa	Pen	5,500	5,630
						70	Frontier	CreU	175	900
61	Lost Soldier, *Sweetwater*	1915	450	2,330,672	20,617,566	8	Tensleep	Pen	3,900	4,097
62	Mahoney, *Carbon*	1930	250	376,124	1,147,317	6	Tensleep	Pen	4,600	4,760
63	Maverick Springs, *Fremont*	1922	1,400	750,469	1,253,497	33	Embar	Per	1,450	1,700
64	Midway, *Natrona*	1930	200	0	175,886	2	Frontier-Muddy	CreU	5,200	5,250
65	Mule Creek, *Niobrara*	1919		129,641	1,447,719	42	Dakota-Lakota	Cre	1,500	1,550
66	Notches, *Natrona*	1923	400	44,770	211,824	2	Tensleep	Pen	2,800	2,850
67	Oregon Basin, *Park*	1927	10,000	7,127,044	23,504,137	60	Embar-Tensleep	Per-Pen	3,500	3,900
68	Osage, *Weston*	1920	10,000	204,305	5,008,703	279	Newcastle (Muddy)	CreU	220	2,154
69	Pilot Butte, *Fremont*	1916	300	176,411	743,163	5	Niobrara	CreU	800	1,000
70	Rex Lake, *Albany*	1923	200	23,060	271,360	3	Dakota	CreU	3,800	3,900
71	Rock Creek, *Carbon*	1918	1,300	938,024	21,711,399	58	Sundance	Jur	3,150	3,250
72	Salt Creek, *Natrona*	1908	21,450	4,953,583	303,602,338	1,900	Frontier	CreU	1,535	2,575
73	Shoshone (Cody), *Park*	1929	540	25,810	78,929	2	Embar	Per	4,300	5,000
74	Sheep Creek, *Fremont*		160	4,492	4,492	2				
75	South Casper Creek and Poison Spider, *Natrona*	1920	240	241,061	3,961,276	18	Sundance Tensleep	Jur Pen	1,400 2,600	1,425 2,700
76	Spindletop, *Natrona*	1928	80	3,393	25,900	4	Sundance	Jur	1,100	1,125
77	Teapot (outside Naval Res.), *Natrona*	1927		12,940	123,681	2	Shale	CreU	1,200	1,600
78	Warm Springs, *Hot Springs*	1917	160	18,636	409,500	19	Embar	Per	700	800
79	Wertz, *Carbon*	1936	640	2,253,242	6,211,812	16	Tensleep	Pen	5,860	6,320

[3] Field abandoned 1941.

[4] Field abandoned 1937.

[5] Carbon dioxide gas.

son has resigned, the efforts to secure adequate price advances have been renewed.

COLORADO

No new oil fields were discovered in Colorado in 1942 and there were no important extensions to old fields. The number of wildcat completions was decreased from 1941, but several of the tests drilled were deep, stratigraphically, and furnished valuable geologic information.

Kiowa County.—As a result of its discovery of oil in 1941 in Kearney County, Kansas, the Stanolind Oil and Gas Co. drilled two deep tests in eastern Colorado along the Kansas line. The first of these tests was No. 1 Snell, on the C.SE.SW. of sec. 7-20S-41W., on what was known as the South Towner block. This well was a dry hole and was abandoned at 5994 ft., ending 74 ft. in the Arbuckle lime. An examination of the cuttings gave the following section.

420	Top Hays
560	Base Hays
910	Dakota
1375	Permian
1900	Blaine
2407	Anhydrite
3800	Topeka
4240	Lansing
4510	Cherokee
5060	Mississippian
5780	Viola
5920	Arbuckle
5995	Total depth
3853	Elevation

Prowers County.—Following the completion of the South Towner well, the Stanolind Oil and Gas Co. spotted a location for its No. 1 Mary House in the C.SW.SE. of sec. 32-24S-41W., 10 miles southeast of the town of Holly and 27 miles south of the Snell location. This well also tested into the Arbuckle lime to a total depth of 6200 ft. The following "tops" were determined by an examination of the cuttings:

685	Permian
1080	Blaine
1769	Anhydrite
3290	Topeka
3730	Lansing
4060	Cherokee
5275	Mississippian
5936	Viola
6130	Arbuckle
6200	Total depth
3501	Rotary table elevation

Rio Blanco County.—The Douglas Creek structure in Rio Blanco County, Colorado, is being tested jointly by Continental Oil Co., The Superior Oil Company of California and the Union Oil Company of California. At the close of the year, the well had reached a depth of 7149 ft., where operations were suspended for the winter.

The Douglas Creek structure is a highly faulted dome, associated with the Rangely anticline to the north and separated from it by a syncline. The average dip of the Mesaverde beds on the south side of Rangely is from 7½° to 8° for about 2 miles; there reversal occurs and in the next 9 miles the Mesaverde dips north at the rate of about 1°. The rate of dip then changes to an average of 5° and continues at this rate to the probable crest of the dome where the Mancos shale is exposed.

The dip of the south flank of the structure near the crest is not more than 2° but increases to 7° 15 miles south of the crest, where the Mesaverde sands disappear under Green River shale. At a fault along the Rangely-Grand Junction highway, near the crest of the dome, southward-dipping Mesaverde beds on the south flank of the dome are in contact with northward-dipping Mancos shale beds.

The maximum closure of the structure may easily exceed 1000 ft. The greater closure is on the south side, where the exact amount cannot be determined but where it exceeds 1000 ft. The closure on the north side is upward of 900 ft. and on the east and west the closure is regional.

The structure, therefore, is well closed and capable of serving as an excellent trap for the accumulation of oil and gas. The test has for its final objectives the producing formations of the Pennsylvanian and Mississippian rocks.

Little Poose Creek, Rio Blanco County.—The Little Poose Creek structure is now being tested by the Rio Oil Co. at a location on the CNL.NW.NE. of sec. 28-3N-88W.

The Little Poose Creek structure, as mapped by Dr. C. E. Manion, formerly employed by the Union Oil Company of California, is an elongated eastward-trending dome about 2 miles long and 1 mile wide, with maximum closure of 900 ft. The surface formation is Dakota sandstone and the objective of the test is the beds below the Sundance (Jurassic). The contract depth is 2600 ft. and the well is now standing at 812 ft. until spring.

Pueblo County.—Late in the summer of 1942, the Continental Oil Co. drilled a deep test on the Steele Hollow structure 10 miles north of Pueblo, Colo. The well was drilled on the C. R. Young farm in the SW.SE.NE. of sec. 11-19S-65W., to granite at a total depth of 6112 feet.

The structure of Steele Hollow is a basinward fold off the flank of the Pike's Peak arch and is a pronounced geological high. The cuttings gave the following section:

790–800	Codell
980–1000	Greenhorn
1190–1220	Dakota Series
1390	Top Morrison
1840	Top Permian (Lykins)
2100–2290	Lyons
2290–5720	Fountain
5720–5860	Glen Eyre
5860–6070	Mississippian
6070–6112	Hard pink granite schist and gneiss
6112	Total depth

MONTANA

Exigencies of war dominated the year's developments in the Montana oil industry and, despite an all-time record production of 8,759,868 bbl., market demand greatly exceeded the supply, for the first time in a decade. This brought new operators to Montana, with a resultant leasing campaign, which points to considerable prospecting during 1943.

A call for 3000 bbl. of additional daily crude runs to Canada was the chief factor in the Montana market in 1942. Montana delivered to Canada an average of 3976 bbl. daily during the year, as compared with 252 bbl. daily during 1941. The close of the year found Canadian deliveries down 25 per cent and Canadian buyers were active in all north Montana oil fields offering contracts for one, two and three years to any producers who will sign.

Alaskan Highway Market.—Chief factor in the Canadian market for oil from Montana in 1943, and in future years, will be the Alaskan highway, where construction and transport traffic will call for enormous amounts of motor fuel. The seriousness of that situation is demonstrated by the United States Army agreement to pay $10 per barrel for Imperial Oil Company's production at Fort Norman oil field, near the arctic circle; the oil to be transported to Dawson Creek, at rail head, through a 400-mile pipe line, also financed by the United States Government.

Standard Oil of New Jersey Enters Montana.—The situation in the Canadian market is believed to be largely responsible for the entrance of the Standard Oil Company of New Jersey into Montana during late 1942. That company purchased the Cut Bank properties of Santa Rita Oil and Gas Co. and its subsidiary, Northwest Refining Co., with its 3500-bbl. refinery at Cut Bank. The properties are being operated by The Carter Oil Co., which, like Imperial Oil Company, Limited, is a drilling and prospecting branch of the Standard Oil Company.

Texaco Buys Properties.—At the same time negotiations were opened which resulted in the purchase by The Texas

Company of The Ohio Oil Company's Kevin properties, together with the Illinois pipe-line system serving Kevin field. These two purchases set off the most spirited leasing campaign in many years, serving to outline part of the 1943 development program in northern Montana. The Carter Oil Co. has 12 lease men at Shelby; The Texas Company has five. Gulf Oil Corporation, The British-American Oil Producing Co., and other large companies have been participating with lesser roles.

Aloe Nose.—Purchased with the Santa Rita properties was a 10,000-acre wildcat block on the Aloe "nose," on the southwest slope of Kevin field, south of the high-gravity oil pools on the west and northwest flanks of the Kevin structure. The Carter Oil Co. probably will drill two or three tests on this block. It is shallow drilling and production is expected in the top 100 ft. of the Madison lime. Wells drilled in this area have had showings of oil, which it is now believed would have responded to acidization.

North Cut Bank.—The Carter Oil Co. acquired also considerable acreage in north Cut Bank, controlling the top of the Hay Lake "nose," called the Darling pool. Many leases in this area had been turned back by The Texas Company, Spruce Oil Co. and others, and The Carter Oil Co. immediately began blocking up the area. Other operators followed and it appears that one of the principal prospecting programs of 1943 will be in the north Cut Bank area, along the Canadian border.

Dupuyer District.—The largest lease play in Montana during 1942 was that in Dupuyer district, west of Pondera oil field, Pondera County, where The Texas Company drilled one well in an effort to locate a south extension of the Cut Bank sand. Cut Bank sand was present, but minus the black chert that marks the principal productive zone in the Cut Bank field. Tops were reported as follows:

1445 Top Colorado
3220 Top Kootenai
3954 Top Ellis
4188 Top Madison
3885 Rotary table elevation

This well was drilled in a lease block of 85,000 acres. The Texas Company's block was not completed when other leasing parties arrived. The Superior Oil Company of California took several leases. A 20,000-acre block adjoining The Texas Company leases on the south was turned over to The Carter Oil Co. and several smaller operators continued leasing on southward until 150,000 acres are now under lease, between the town of Choteau, Teton County, and the Cut Bank oil field.

Blackleaf Structure.—Of the secondary blocks, A. B. Cobb, of Great Falls, has one of the most promising, northwest of The Texas Company's test on a local fold known as Blackleaf structure, drilled to 2833 ft. before winter weather closed it down. The Texas Company and other operators are awaiting the outcome of the Cobb well before making any new location. The Carter Oil Co. is expected to do some geophysical work in the district in the spring.

Willow Creek.—Farther south, in the edge of the overthrust belt that parallels the Rocky Mountains, the Willow Creek structure is expected to have a test this year. Shell Oil Co. has been paying rental for several years after having done extensive geophysical work that revealed that the structural "high" is about 3 miles east of the surface "high" mapped by Stabinger for United States Geological Survey. The Durham interests of West Virginia drilled the surface "high" in 1942, abandoning the well in the red beds after having found showings of gas.

New Lime Horizon, Reagan Pool.—The most important development of the drilling season was the discovery of a new lime horizon on the Twin River nose northwest of Cut Bank field, where the Reagan No.

2 well, ¾ mile from the discovery well, was carried 80 ft. into the Madison lime, getting 20 ft. of saturation, 38° gravity oil. It was drilled too deep and bottom water was plugged off only after considerable difficulty. The No. 2 well flowed an initial of 100 bbl. of oil per day. The No. 1 was deepened to the new horizon but the completion work was interrupted by winter weather.

Blackfeet Nose.—The development of the Reagan horizon brought attention to the three other structural noses of north Cut Bank, known as the Blackfeet nose, the Hay Lake nose and the Border nose, mapped by the United States Geological Survey. Tests to the Reagan horizon on each one of these noses is expected during the year 1943. Two or three wells drilled to the Madison lime contact in the area have had showings but none has been acidized, neither has any well been carried any distance into the Madison lime.

Oil in Gas Territory.—Proof that north Cut Bank is the most promising undeveloped area of Cut Bank was further afforded by an 800-bbl. well drilled in the northwest edge of the recognized gas area by Glacier Production Co., in sec. 8, T. 35 N., R. 5 W. Drilled on a gas unit with expectation of a small gas well, it unexpectedly found oil in the upper Sunburst sand, and now rates as the largest well in the field, second in initial production only to Santa Rita-Lander No. 1, which had an initial of 1800 bbl. and which has produced more than $1,250,000 worth of oil since its completion in 1936.

No drilling followed the Glacier Production Company's discovery. It is in the recognized gas area in which the Petroleum Administration for War has required that 640 acres be ascribed to each well. No other location in the district has yet been approved. Glacier Production controls all of the offset acreage within the McGuiness unit.

Midway Structure.—The only successful wildcat in new territory completed during 1942 was R. C. Tarrant's on Midway structure, east of the town of Conrad in Pondera County, 30 miles south of Kevin oil field. His Woods No. 1 well was started as a Devonian test and in the Sunburst sand he unexpectedly encountered oil estimated at from 5 to 20 bbl. per day. He continued to the Madison lime, where he had a second showing of oil with water. When he began to run casing he discovered that his newly arrived 10-in. was line pipe and not casing. Unable to get another string of 10-in., he ran 8-in., and was forced to reduce his hole when a second flow of water was found near the top of the Madison lime. It is doubtful whether he can drill through the hard, massive limestone with small tools. He is pledged to drill the Devonian in this or a subsequent hole.

Meantime Tarrant started two more shallow tests to determine the extent of the Sunburst sand pool. One of these, Tarrant-Destaffany No. 1, northwest of the discovery well, found about 5 bbl. of production in a hard Sunburst sand. The other well is uncompleted.

Conrad Butte.—A structural nose running up onto Midway, known as Conrad Butte structure, was leased by Tarrant after the showing of oil in the Woods well, and a validation hole was carried to the gas sands of the Colorado, using a spudder. This is to be replaced by a standard rig in the spring. A well drilled by Big Eleven syndicate on this nose in 1927 had a good showing of oil and gas at the Madison lime contact. It is believed that with acidization it might have made a well.

Sweetgrass Hills.—United States Geological Survey came forward with a new structure in the Sweetgrass Hills, mapped by C. E. Erdman, called Kicking Horse structure. It is a small fold near the West Butte of the Sweetgrass Hills, northwest of Berthelote, where there is one small well producing from the Sunburst sand. The map shows an adjacent fold to the west, known as Simons Creek fold. Doubtless a test will be drilled on Kicking Horse in 1943, as it has been leased by a group of Kevin independent operators, headed by Charles Wrighter, organizer of the successful Rimrock Oil Co. and High Gravity Oil Co. The Carter Oil Co. has taken extensive leases in the general area.

A revival of activity in the long neglected proved areas of the Sweetgrass Hills is expected the spring of 1943. It is reported that Montana-Dakota Utilities Co. is acquiring control acreage on Bears Den structure, on which some small oil and gas wells have been drilled. Completion of a test to the lime and further drilling on Flat Coulee structure, likewise proved for oil, is projected. E. B. Coolidge, of Hardrock Oil Co., has acquired acreage on the structure, which is controlled by J. H. Hamilton of Great Falls.

Spacing Rules.—It is generally conceded that new pools will be required to increase 1943 production over the 1942 record, and operators declared that only a relaxation of M-68 spacing rules will make this possible. In Cut Bank field 90 wells will be required to maintain present production of 15,000 bbl. per day and in Kevin field 60 wells to maintain 5000 bbl. per day.

Cut Bank has been developed under the rule of one well to 40 acres. An exception was obtained to permit drilling of the southeast corner rather than the center of the forty, to fit the development pattern in the new Tribal pool at the south end of Cut Bank. There are not 90 proved locations open on 40-acre spacing, and operators are asking the Petroleum Administration for War for 20-acre spacing. A program of 59 wells has been announced thus far on 40-acre spacing, as follows: The Texas Company, 18; Glacier Production Co., 16; Santa Rita Oil and Gas Co. (Carter), 15; A. B. Cobb, 8. Few of the smaller independents have undrilled 40-acre locations.

There is the possibility of additional locations in the phenomenal south Cut Bank district, the limits of which have not been defined. It is believed that the south limits are not far beyond present production. Chief entrant in the 1942 development of the south extension was Trigood Oil Co., of Casper, Wyo., which drilled 13 wells on tribal leases acquired at the summer sale of the Blackfeet council.

Kevin, Sunburst Field.—All of Kevin field is being leased. The Texas Company is far ahead of all others in taking up open tracts, both within the producing area and along the north and south limits of present production. Prospects for a deep test in the Kevin field, long projected, rest largely with The Texas Company, which pretty well controls the field through its recent leasing and the purchase of the Ohio Oil Company's properties. The necessity of finding more oil to supply the Texas Company's refinery at Sunburst is the factor most likely to hasten a test to horizons below the "big lime." Presence of oil below the Madison lime has been established by showings in the Frazier-Rice well, in the northeast corner of the field, and in other wells drilled to 3000 ft. or more. None of these wells has been drilled since the introduction of acidization.

WYOMING

Elk Basin, Park County.—The most important development in the Rocky Mountain Region in 1942 was the discovery of "black oil" in the old Elk Basin field in northern Wyoming. The discovery well, No. 1 E-T Henderson, was drilled in the NE.NE.NE. of sec. 31-58N-99W., jointly by Minnelusa Oil Corporation, Yale Oil Corporation, and Henderson Producing Co. On completion, the well flowed 80 bbl. of oil an hour through a choke on 5-in. casing, cemented at 4490 ft. from Tensleep sand at 4488 to 4538 ft. Some oil saturation was reported in the Embar lime, top at 4463 ft., but no production test was made.

The Elk Basin field was one of the first producing oil fields in Wyoming. The first test for oil was drilled in 1915. The discovery well found oil in the Torchlight and Peay sands at 1070 and 1280 ft., respectively. These sands are members of the Frontier series and are known locally as the first and second Frontier sands.

The field was developed rapidly and to date about 157 wells have been completed, of which seven produce gas from the Dakota sand. The Dakota sand gas was discovered in November 1920 by Midwest Refining Company.

In 1923, a pipe line was laid to Billings and other small towns along the route, where gas has been marketed since that time. In 1931 this line was connected by a branch line to the Dry Creek field. At present, Elk Basin gas can be turned into the Bozeman line or Dry Creek gas can be run through the line to Billings.

In 1941, Mackinnie Oil and Drilling Co. completed a Dakota-sand gas well in South Elk Basin, which was a very important discovery and opened up important gas reserves to development. South Elk Basin is an area of fault blocks where original pressures may be expected over widely separated areas. The decline of pressure in the old part of the field has reached a point where it has been necessary to draw on desulphurized gas from Garland field to augment the supply for Billings, Montana.

The first producing oil well in the Graybull sandstone member of the Cloverly formation was completed in 1939, by Henderson Producing Co.-Minnelusa Oil Corporation. This well, known as No. 1-H-11 on Elk 11, is in the SE.SE.NW. of sec. 35-9N-23E., on the Montana side of the line. On a drill-stem test in Dakota sand at 2867 to 2877 ft., the well made 10 bbl. of oil a day with 500,000 cu. ft. of gas, but through the tubing it gauged 1,500,000 cu. ft. of gas with a spray of oil.

The Elk Basin structure is formed in Colorado shale (Upper Cretaceous). It is a narrow, highly faulted symmetrical anticline trending northwest-southeast, about 12 miles long. The steepest dips are to the northeast. The normal dip is to the southwest. The structural closure cannot be determined definitely because the limiting syncline on the east is covered by alluvium, but the closure is believed to be about 3000 feet.

The Elk Basin fold lies about 15 miles east of the line of intense deformation marking the front range of the Rocky Mountains. It is near the northern end of the Big Horn Basin, a vast geosyncline lying mostly in Wyoming. The Beartooth Mountains rise to the west and the Big Horn Mountains form the eastern side of the basin.

The Elk Basin structure, as stated, has a general northwest-southeast trend and is cut by a series of three sets of faults. Two of these sets are normal transverse faults and the planes follow a general northeast-southwest direction. The third set is composed of strike faults and follows the general trend of the crest of the anticline through the fault blocks at the south end of the field.

The northeast-southwest faults with displacements down on the southeast side apparently occurred first, as the faults with approximately the same strike but down on the northwest side were found to have cut the planes of the first series.

All of the beds above the Cloverly, including those in the escarpment that encircles the Elk Basin field, are of Upper Cretaceous age and are divided into two groups called the Colorado and Montana. Oil is produced from two sands in the Frontier known as the Torchlight and Peay. Locally, these sands are called first and second Frontier.

The lowest exposed rocks in the field belong in the upper part of the Cody shale of Upper Cretaceous age. This shale has a thickness of 1700 ft. above the top of the first Frontier sand. The Frontier formation has an approximate thickness of 325 ft. and consists of two sands separated by shale. The Cloverly formation is of Lower

Cretaceous age and had a computed thickness at Elk Basin of 480 ft. It contains the so-called Greybull sand, the important producer of gas in this field. The United States Geological Survey separates this formation into three parts; an upper shale member called the "Rusty Beds," a middle sandstone member and a thick basal conglomerate. This group of rocks is commonly called the Dakota group in other parts of Wyoming.

Cody Dome (*Shoshone*), *Park County*.—The Husky Refining Co. discovered oil in the Tensleep sand at Cody dome in 1942. The discovery well, No. 2 Stump, SE.SW.SW. of sec. 21-53N-101W., produced initially at the rate of 200 bbl. of oil a day from Tensleep sand at 4625 to 4795 ft. The oil has a gravity of 28°A.P.I.

The development of the Shoshone anticline field was started in July 1938, by the completion of Paul Stock's No. 1 Bertha M. Rousseau, on the SE.SE.NE. of sec. 20-53N-101W. This is not the discovery well of the field but it is an important extension of the producing area. The Stock well was completed in Embar lime at a total depth of 4809 ft. and flowed at the rate of 10 bbl. of oil an hour after treatment twice with acid, a total of 2000 gallons.

The Shoshone anticline is formed in beds of Frontier age. It is 5 miles long with 1320 ft. of closure, and contains 680 acres above the closing contour.

This structure has been known for many years and numerous tests were drilled in the early development of Wyoming fields, which were completed in the shallow Muddy sand at about 800 ft. as small pumping wells. From 1924 to 1928 several wells were drilled to deeper horizons, some of which developed good showings of oil in the Greybull sand. The deep test of the structure was completed in 1929 by The Ohio Oil Co. in the NW.NW. of sec. 27-53N-101W. This well was completed for an initial production of 45 bbl. of oil per day from Embar lime at 4752 to 4765 ft., after plugging back from a total depth of 4780 ft., where sulphur water was encountered. The top of the red beds was logged at 3560 feet.

Horse Creek, Laramie County.—The General Petroleum Corporation discovered oil at Horse Creek early in the fall of 1942. The discovery well, No. 78-31-Government, is on the SW.SE.SE. of sec. 31-17N-68W., and was completed in Dakota sand at 5451 to 5514 ft. The well had a hydrostatic head but no gas, and did not flow. It pumped initially 580 bbl. of oil a day of an average gravity of 30.4°A.P.I. The following "tops" were determined by an examination of the cuttings:

4210	Top Niobrara
5265	Top Muddy
5419	Top Dakota
5451	Top Lakota
5514	Top Morrison
5531	Total depth
6780	Approximate elevation

The discovery of oil at Horse Creek probably is the first geophysical discovery in the Rocky Mountains, where some evidence of structure was not known in advance of the geophysical work, and also the first discovery of oil in the Rocky Mountain area on a gravity anomaly.

During the summer and fall of 1940 the Independent Exploration Co. made a gravity-meter survey of the area from Cheyenne to Wheatland between the mountain front and the axis of the Denver Basin, which indicated a number of anomalies. These were leased and then turned to the General Petroleum Corporation. Before the discovery well was drilled, the survey was checked by seismograph.

In the Horse Creek area, there are no surface structural indications or peculiar topography that would suggest the presence of the structure. On the contrary, the area was selected because the very late Tertiary surface beds would conceal structure in the area, and there could be structures not indicated at the surface and unknown to geologists.

Pilot Butte, Fremont County.—The British-American Oil Producing Co. and The Superior Oil Company of California discovered oil in the Tensleep sand at 6184 to 6323 ft., in No 1 Tribal well, SW.SE.SW. of sec. 15-3N-1W., in the old Pilot Butte field on the Shoshone Indian reservation in Fremont County, Wyoming. The well initially made 750 bbl. of 24.7° gravity oil.

The Pilot Butte field was discovered May 26, 1916, with the completion by Standard Exploration Co. and Midwest Refining Co. of a well on the NE.NE.NE. of sec. 17-3N-1W. This well found its production in shale, either Steele or Niobrara, at 1255 to 1306 feet.

In 1930, the Kinney-Coastal Oil Co. drilled a deep test in the SE.SW. of sec. 22-3N-1W., which developed an open flow volume of 63,000,000 cu. ft. of gas in Muddy sand at 3362 ft. and was then drilled 135 ft. into the Sundance (Nugget) sand, to a total depth of 4653 ft. before plugging back to complete as a gas well.

In 1931, Kinney-Coastal Oil Co. drilled its No. 1 Chatterton-Weeks, C.SW.NE. of sec. 22-3N-1W., which developed an open flow of gas from Muddy sand at 3565 to 3631 ft. It gauged initially 2,000,000 cu. ft. of gas.

Early in September 1942, The Superior Oil Co., failing to find oil production in Tensleep sand in its No. 1 Stock CEL.NE.-NE. of sec. 21-3N-1W., plugged the well back to the Embar lime at 6150 to 6210 ft. and completed it for an initial production of 500 bbl. of 28° gravity oil. After the well had been produced for a short time it began making water and had to be abandoned.

The Pilot Butte structure is developed in Pierre shale and is approximately 4 miles long, 2 miles wide, has approximately 600 ft. of closure and is more or less complexly faulted. There are about 2560 acres above the lowest closing contour.

Circle Ridge, Fremont County.—In 1942, the Continental Oil Co. completed the development of the Circle Ridge field begun in 1941. The field was discovered 19 years ago by the Union Oil Company of California with the completion of a well in Tensleep sand at 592 to 655 ft., for an initial production of 132 barrels.

Circle Ridge is a small dome on the Maverick Springs line of folding with sharply dipping flanks and 2000 ft. of closure.

North Hiawatha, Sweetwater County.—The Vermillion Oil Co. and Johnson and Horton completed a 10-bbl. well in the Wasatch formation at 2627 to 2645 ft., which may prove an important extension to the Hiawatha field. The well is in the SW.NE.NE. of sec. 6-12N-99W.

Sherrard Dome, Carbon County.—Sinclair Wyoming Oil Co. discovered gas on Sherrard dome in April 1942, in its No. 1 Mary Carter on the NE.SE.SE. of sec. 31-25N-88W. The well produced initially 8,000,000 cu. ft. of gas, under 1050 lb. pressure, from the Lakota sand, through perforations in the 7-in. casing between 2950 to 2985 ft. and 3024 to 3064 ft. Before completion, the well was drilled to 5185 ft.; 138 ft. in the Tensleep sand. It was then plugged back to 4433 ft. A small showing of oil followed by water was encountered in the top of the Tensleep. Rotary table elevation was 6510 feet.

The Mary Carter well was located by seismograph survey. The field is on the Separation Flats-O'Brien Springs line of folding but surface beds do not indicate doming at this point. Early drilling operation indicated doming about one mile northwest of the Mary Carter well.

Acknowledgment

All of the statistical information contained in this report was taken from the files of Petroleum Information. The information in the text covering operations in Montana was contributed by O. I. DeSchon, editor of the *Montana Oil and Mining Journal* at Great Falls.

Oil and Gas Developments in Tennessee in 1942

BY KENDALL E. BORN[*]

PRODUCTION of crude oil in Tennessee during 1942 was approximately 8600 bbl., a decrease of 6500 bbl. from the production of 1941, and the lowest since 1934.

As usual, the greater part of the production was from the Mississippian limestone pools in Scott and Morgan Counties. Some half dozen wells in Fentress and Clay Counties pumped intermittently produced about 1000 barrels.

Natural gas was marketed from wells in Morgan and Fentress Counties for consumption in the Sunbright and Jamestown areas respectively. Figures are not available for the Morgan County production but 7,378,000 cu. ft. of natural gas was produced in the Jamestown gas field from six wells.

The production of oil by counties is shown in Table 1.

DEVELOPMENTS

Drilling activities reached the lowest ebb since 1933. Only 10 wells were spudded during the year, one of which was drilling on Dec. 31, 1942. Of the nine completions, two were gas wells in the proven area south of Jamestown in Fentress County and seven were dry holes. The total footage drilled during the year was 14,198 ft.; the average depth of wells was 1578 ft. The completions are listed in Table 2. The distribution of tests according to physiographic divisions is given in Table 3.

East Tennessee.—One well was drilled to 4219 ft., the second deepest well in the state, in Campbell County. The test was in the highly disturbed Valley and Ridge Province, an area long considered the most unfavorable in the state for the accumulation of oil and gas.

Cumberland Plateau.—There were no completions in the Cumberland Plateau area, although an old well drilled deeper found oil from 935 to 965 ft. in the Mississippi lime. This test has created a considerable amount of interest in the area and an active leasing campaign was underway early in 1943.

TABLE 1.—*Oil Production in Tennessee in 1942*

County	Number of Wells Pumped	Production, Bbl.	
		1941	1942
Scott and Morgan....	23	10,198	7,656
Clay and Fentress....	7	5,xxx	1,xxx

Eastern Highland Rim.—Five completions on the Eastern Highland Rim brought in two small gas wells in Fentress County, which will be used to augment the supply for Jamestown. The producing horizons are shaly limestones of Ordovician (Trenton) age. Two wells in this area were drilled to the upper part of the Knox dolomite group. The most significant test during the year was the Stanolind Oil and Gas Company's test in Putnam County. This well, on a well-defined surface structure, was abandoned in the upper Knox dolomite group at 2130 ft. A show of oil was logged in the Knox at 1653 to 1661 ft.

Northern Highland Rim.—Three tests widely separated in the Northern Highland Rim were dry.

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Mississippi Embayment.—For the first time in more than 10 years, there were no completions in the Mississippi embayment area in western Tennessee. Much acreage, assembled during an active leasing campaign 5 years ago, has lapsed.

TABLE 2.—*Oil and Gas Tests Drilled in Tennessee during* 1942

County	Location	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested	Drilled by	Remarks
Campbell.....	0.7 mi. E. of Jacksboro	4,219	Knox (Ord)	Cambrian?	Stoll et al.	
Fentress......	3.2 mi. SW. of Jamestown	976	Middle Mis	Trenton (Ord)	Joe Young	Commercial gas at 968 to 971
Fentress......	3.1 mi. SW. of Jamestown	1,050	Middle Mis	Trenton (Ord)	Joe Young	Gas well at 720
Fentress......	10.4 mi. NW. of Jamestown	800	Middle Mis	Trenton (Ord)	J. M. Murphy et al.	
Fentress......	7.2 mi. W. of Jamestown	1,923	Middle Mis	Knox (Є-Ord)	Travis Smith et al.	Tested Upper Knox in area of Trenton production
Houston......	3.5 mi. SW. Tennessee Ridge	1,502	Middle Mis	Stones River (Ord)	B. A. Eubanks	
Macon.......	2 mi. NW. Red Boiling Springs	800	Lower Mis	Stones River (Ord)	Macon County Oil & Gas Co.	
Putnam......	4.6 mi. E. of Cookeville	2,130	Middle Mis	Knox (Є-Ord)	Stanolind Oil & Gas Co.	Tested Upper Knox on a well-defined surface structure
Robertson....	1 mi. NW. of Barren Plains	798	Middle Mis	Trenton (Ord)	Leeper Oil Co.	

TABLE 3.—*Physiographic Distribution of Wells Drilled in Tennessee in* 1942

Physiographic Division	County	Wildcat	In Proven Fields	Oil Wells	Gas Wells
East Tennessee....................................	Campbell	1	0	0	0
Eastern Highland Rim............................	Fentress	2	2	0	2
	Putnam	1	0	0	0
Northern Highland Rim..........................	Macon	1	0	0	0
	Robertson	1	0	0	0
	Houston	1	0	0	0

Development and Production in East and East Central Texas in 1942

By D. V. Carter* and K. M. Fagin†

Six new oil fields were discovered in the East and East Central Texas district during 1942. The Coke and Quitman fields, in Wood County, at this time appear to be the two most important oil discoveries for the year. The four other oil fields discovered were Concord, in Anderson County; Kildare, in Cass County; Weiland (Club Lake), in Hunt County; and Larissa, in Cherokee County. The Rodessa lime in the Chapel Hill field, Smith County, provided the only new oil zone in older fields.

The Hawkins field, Wood County, was the most active in drilling operations, 125 new wells being completed during the year. The Chapel Hill field tied the Coke field for second place with 30 completions each. The third most active field was Kildare, with 10 completions. Like the other oil-producing districts of the country, wartime restrictions reduced the number of oil and gas-well completions to 265 in 1942, compared with 964 completions in 1941. This represents a drop of 72 per cent and only a little more than one half enough to replace the 437 producing wells abandoned in the district during the year.

In addition, the number of producing wells temporarily shut down nearly tripled, for two principal reasons: (1) the rule of the Petroleum Administration for War preventing operators from equipping more than one well on each 10 surface acres with pumping or artificial-lift equipment, and (2) the Railroad Commission's issuance of various orders permitting the transfer of allowable for wells having high water-oil ratios and high gas-oil ratios to other wells capable of producing the same with less waste of reservoir energy.

No changes were made in prices of crude oil in the district during 1942.

Production and Proration

The district produced 158,928,281 bbl. of oil and distillate during 1942, compared with 163,566,695 bbl. during 1941, which represents a decrease of 3 per cent. The East Texas field produced 120,680,595 bbl. of oil, compared with 130,377,793 during 1941; a reduction of 9,697,198 bbl., or 7.4 per cent. The production of this field represents 75.9 per cent of the district total, compared with the 79.7 per cent that it furnished in 1941. The district had an estimated basic daily oil allowable of 623,242 bbl. on Dec. 31, 1942. Approximately 31.8 per cent of the production in Texas during 1942 was supplied by this district, compared with 33 per cent during 1941.

Changes in the annual production of newer and flush fields in this district are attributable either to a difference in the number of wells producing during the year or to changes in basic allowable and number of shutdown days due to shifting market conditions brought on by the war. All regularly prorated fields in the district were shut down 123 days. Major exceptions were the East Texas field, closed 128 days; Hawkins, shut down 106 days; and Cayuga, Sulphur Bluff, Talco, and Rodessa, which

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TABLE 1.—*Oil and Gas Production in East and East Central Texas*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
1	Barron,[1] *Limestone*	1939	0	300	3,552	1,412
2	Bazette, *Navarro*	1939	100	20	188,093	31,501
3	Boggy Creek, *Anderson, Cherokee*	1927	960	0	5,112,383	71,793
4	Bolivar, *Denton*	1937	600	200	14,446	1,518
5	Bosque, South, *McLennan*	1902	2,500	0	113,631	3,386
6	Buffalo,[2] *Leon*	1934	10	7,500	15,622 17,387	3,009 0
7	Carthage,[1,5] *Panola*	1936	0	2,450y	257,432	104,928
8	Cayuga,[2] *Anderson, Henderson, Freestone*	1934	9,700	3,000	1,935,568C 25,774,230	520,744C 4,006,520
9	Cayuga (Trinity),[2] *Anderson, Henderson, Freestone*	1938	40	y	319,074C 21,263	51,520C 5,494
10	Chapel Hill,[2] *Smith*	1938	3,700	10,000	1,102,567 678,103	529,498 471,502
11	Coke, *Wood*	1942	1,200	0	53,183	53,183
12	Collinsville, *Grayson*	1938	100	0	35,052	3,672
13	Concord, *Anderson*	1942	20	0	11,609	11,609
14	Corsicana,[6] *Navarro*	1895	6,710	y	14,591,058	139,061
15	Currie,[7] *Navarro*	1921	475	y	6,940,687	37,302
16	East Texas,[2] *Cherokee, Gregg, Rusk, Smith, Upshur*	1930	136,000	2,000	12,722 1,831,943,446	662 120,680,595
17	Flag Lake, *Henderson*	1937	405	40	539,730	51,819
18	Ginter, *Angelina*	1936	60	0	37,364	5,762
19	Grapeland,[2] *Houston*	1936	40	6,000y	3,815,049C 135,700	2,214,094C 24,855
20	Grosbeck, *Limestone*	1913 1924 1941	y y 10	2,360y 60y 0	0 y 2,276	0 0 2,133
21	Hawkins,[2] *Wood*	1940	8,200	4,850 300 [10]	12,147 6,898,543	7,505 5,445,249
22	Hemby (Elkhart),[1] *Anderson*	1938	0	1yy	4,011	42
23	Huntington, *Angelina*	1936	100	0	13,971	1,050
24	Joaquin,[1,15] *Shelby*	1931	0	6,000y	155,815C	53,840C
25	Kildare, *Cass*	1942	500	100	132,682	132,682
26	Larissa, *Cherokee*	1942	40	0	1,714	1,714
27	Lone Star, *Cherokee*	1938	100	y	51,861	14,967
28	Long Lake,[2] *Anderson, Freestone, Leon*	1933	10,000	y	4,573,659C 5,790,111	1,376,322C 1,304,257
29	Long Lake, East, *Anderson*	1941	300	y	182,523	130,531
30	Lott, *Falls*	1937	3yy	0	31,899	1,130
31	Marion County (shallow)	1939	670	x	286,912	60,798
32	Mexia, *Limestone*	1920	3,920	y	98,390,061	562,231
33	Nacogdoches,[16] *Nacogdoches*	1865	1,000y	0	434,587y	1,789
34	Navarro Crossing,[2] *Houston*	1938	1,040	3,450	2,375 724,878	0 133,024
35	Nigger Creek, *Limestone*	1926	170	y	2,999,406	0
36	Oakwood,[2] *Leon*	1939	80	1,000	231 14,331	0 0
37	Opelika,[2] *Henderson*	1937	x	7,000y	3,281,961C 19,314	1,698,255C 0
38	Panola (Bethany),[2,15] *Panola*	1921	60	23,000y	33,199 63,911	12,855 6,021

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Distillate field.

[2] Oil and distillate field. Upper figure distillate production, lower figure oil production. C indicates cycling plant.

[5] Includes Hull and Pulaski Ferry.

[6] Includes Mildred, Angus-Edens, Hodge, Birk Rice, Oil Ridge, and Old Powell Shallow.

[7] Includes North Currie.

[10] 300 surface acres Woodbine gas area not underlain by oil and approximately 3150 acres of Woodbine gas underlain by oil. Sub-Clarksville gas area covers approximately 4850 surface acres. Total proved surface acres, both pays, oil and gas is 8500.

[15] Field extends into Louisiana.

[16] Includes Chireno and Jennings.

TABLE I.—(*Continued*)

Line Number	Total Gas Production Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
				During 1942		End of 1942			Number of Wells						
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
1	2,725	1,364	6	1	0	1	0	5	0	0	2,659	2,147		61	
2	*x*	*x*	9	1	0	0	8	0	0	8	1,300*y*	*y*		42	
3	*x*	*x*	33	0	0	0	17	0	0	17	1,680*y*	*y*		38	
4	*x*	*x*	10	0	0	0	1	3	0	1	*y*	*y*		40	
5	*x*	*x*	59*y*	0	11	3	35	0	0	35	*y*	*y*		41	
6	7,593	1,407	10	0	0	1	0	9	0	0	2,502[3] 2,620[4]	2,108[3] 2,502[4]		48 25	
7	15,085	6,188	18	7	0	0	0	15	0	0	*y*	*y*		55 64 61	
8	122,752	32,585	336	4	7	4	279	46	128	151	1,750	1,306	PM	63 29	
9	22,360	2,102	6	0	0	0	1	5	1	0	*y*	*y*		*y* 32	
10	17,663	8,619	54	30	0	0	39	15	36	3	2,900 *y* *y*	*y* *y* *y*		74 63 43	
11	*y*	*y*	30	30	0	0	30	0	30	0	2,705	2,705		27	
12	*x*	*x*	2	0	0	0	2	0	0	2	*y*	*y*		29	
13	0	0	1	1	0	0	1	0	0	1	1,620	*y*		12	
14	*x*	*x*	2,941*y*	0	7	0	609	0	0	609	*y*	*y*		32 & 27	
15	*x*	*x*	55*y*	0	0	0	14	0	0	14	*y*	*y*		40	
16	692,023[8]	45,847[8]	27,387	8	345	836	25,158	4	16,637	8,521	1,620	1,017		58 39 38[9]	
17	*x*	*x*	25	3	1	0	12	1	0	12	1,394	*y*		45	
18	*x*	*x*	4	0	0	0	4	0	0	4	*y*	*y*		21	
19	94,649	75,131	42	3	0	0	1	34	1	0	2,535	2,350	PM	63 43	
20	11,800*y* *x* *x*	*y* *x* *x*	30*y* 5 1	0 0 0	0 0 0	0 0 0	0 0 1	*y* 3 0	0 0 1	0 0 0	275 875 *y*	*y* *y* *y*		Gas Gas 41	
21	1,328	874	376	125	0	0	373	3[11]	361	12	*y* 1,990[12]	*y* 1,903[13]		25[14]	1.6
22	1,162	15	2	0	1	0	0	1	0	0	2,200	*y*		59	
23	*x*	*x*	12	0	0	0	1	0	0	1	*y*	*y*		24	
24	36,966	16,307	27	3	0	0	0	17	0	0	2,550	*y*		37 48	
25	239	239	10	10	0	0	9	1	9	0	2,750	2,499		41	
26	3	3	1	1	0	0	1	0	1	0	*y*	*y*		48	
27	*x*	*x*	3	0	1	0	1	0	0	1	1,375	*y*		35	
28	*y*	60,583	222	4	0	7	139	68	113	26	2,440	2,129	PM	63 41	
29	*x*	*x*	12	1	0	0	12	0	12	0	*y*	*y*		43	
30	*x*	*x*	5	0	0	0	3	0	0	3	*y*	*y*		29	
31	*x*	*x*	45	1	1	1	37	0	0	37	*y*	*y*		42	
32	*x*	*x*	573*y*	0	6	3	208	0	0	208	*y*	*y*		35	
33	*x*	*x*	50*y*	0	1	0	38	0	0	38	*y*	*y*		23	
34	5,081	52	31	1	0	6[17]	21	2	16	5	2,700*y*	2,593[18]		41 37	
35	*x*	*x*	75	0	1	1	0	0	0	0	*y*	*y*		40	
36	51	0	6	0	1	2	0	0	0	0	*y*	*y*		*y* 36	
37	*y*	27,925	14	3	0	1	0	13	0	0	3,845 *y*	*y* *y*	PM	59 39	
38	153,719	1,688	355	3	8	*y*	4	78	0	4	*y*	*y*		60 28	

[3] South dome.
[4] North dome.
[8] Includes estimate of gas produced with oil and gas produced from gas wells.
[9] Upper sand.
[11] Producing gas from sub-Clarksville.
[12] Corrected to 4075 ft. subsea.
[13] October 1, 1942.
[14] Field shows marked gravity segregation ranging from 15° to 30°.
[17] Gas wells.
[18] April 1942.

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
1	L. Glen Rose	CreL	L	15	5,584	5,611	25	AF	Travis Peak	6,051
2	Woodbine	CreU	S	23	2,992	3,008	15	AF	Woodbine	3,008
3	Woodbine	CreU	S	25	3,632	3,666	34	Ds	Fredericksburg	4,648
4	Cisco	Pen	S, L	y	1,630	1,683	25	AF	Ellenburger	2,530
5	Basal Walnut	CreL	DL	y	450	475	3	AF	Trinity	1,800y
6	Woodbine	CreU	S	20	5,273 5,634	5,933 5,774	22[3] 44[4]	D	CreL (Washita)	6,300
	L. Glen Rose		OL	19	4,984	5,040	20	MC		
7	L. Glen Rose		L	23	5,930	5,940	10	D	Travis Peak	6,019
	L. Glen Rose (Pettit)	CreL	OL	y	5,825	5,905	y	MC		
8	Woodbine	CreU	S	25	3,680	3,758	Gas 54 Oil 18	AF	Trinity	9,085
9	L. Glen Rose	CreL	L	20	7,412	7,612	10	AF	Trinity	9,085
	Paluxy		S	21	5,600	5,700	50y			
10	L. Glen Rose (Rodessa)		OL	10–18	7,400	7,500	25	A	Travis Peak	8,600
	L. Glen Rose (Pettit)	CreL	OL	10–18	8,000	8,100	24			
11	Paluxy	CreL	S	21	6,300	6,360	55	A	Paluxy	6,416
12	Strawn	Pen	S	y	3,848	4,219	20	ML	Strawn	4,219
13	Woodbine	CreU	S	25	4,522	4,540	10	D	CreL	5,217
14	Nacatoch Corsicana (Wolf City)	CreU	S	y	800	1,260	12–20	AF	Woodbine	3,570
15	Woodbine	CreU	S	22	2,930	2,990	20	AF	Woodbine	3,646
16	Woodbine	CreU	S	25	3,632	3,665	35	Shoreline	Paluxy	5,020
17	Woodbine	CreU	S	23	3,050	3,075	5	AF	Travis Peak	6,518
18	Carrizo	Eoc	S	y	2,186	2,200	10	ML	Wilcox	2,265
19	Woodbine	CreU	S	25	5,976	6,083	25	A	Woodbine	6,300
	Nacatoch	CreU	S	25	710y	750y	40y	AF		
20	Woodbine	CreU	S	20	2,945	2,960	15	AF	Woodbine	3,208
	L. Glen Rose (Pettit)	CreL	L	y	5,685	5,776	y	AF	L. Glen Rose (Pettit)	5,796
21	Sub-Clarksville	CreU	S	y	3,910	4,225	Gas 5 Gas 80 Oil 110	AF	Paluxy	6,535
	Woodbine			27	4,475	4,875				
22	Woodbine	CreU	S	25	5,409	5,422	y	AD	Woodbine	5,487
23	Queen City	Eoc	S	y	1,458	1,483	8	ML	Mount Selman	1,490
	U. Glen Rose				4,097	4,107	10			
24	L. Glen Rose	CreL	L	y	5,070	5,138	30	D	Glen Rose	5,138
25	L. Glen Rose (Gloyd)	CreL	L	16	5,973	6,023	Gas 25 Oil 15	AD	L. Glen Rose (Dees-Young)	6,205
26	L. Glen Rose (Pettit)	CreL	OL	Por	10,163	10,212	y	AD	Travis Peak	10,604
27	Woodbine	CreU	S	y	4,006	4,010	4	Af	Woodbine	4,015
28	Woodbine	CreU	S	25	5,170	5,250	Gas 24y Oil 8	A	Trinity	9,966
29	Woodbine	CreU	S	24	5,335	5,415	8	D	Woodbine	5,417
30	Buda, U. Washita	CreL	DL	y	1,250	1,275	10	AF	Edwards	1,500
31	Tokio	CreU	S	y	2,336	2,346	10	A	Tokio	2,346
32	Woodbine	CreU	S	25	3,000	3,085	50	AF	CreL or older	8,847
33	Weches	Eoc	SH	y	80	364	y	ML	CreL	5,484
34	Woodbine	CreU	S	22	5,750 5,874	5,900 5,895	Gas 31 Oil 7	DF	Woodbine	5,968
35	Woodbine	CreU	S	25	2,820	2,870	15	AF	Woodbine	3,509
36	Woodbine	CreU	S	y	5,838	5,841	3	D	Woodbine	5,913
37	L. Glen Rose (Rodessa)	CreL	LS	19	8,170	8,180	y	AF	L. Glen Rose (Pettit)	9,740
	U. Glen Rose			19	7,195	8,028	40			
38	Various[19]	CreU CreL	S, L	y	1,100	5,700	40	A	Salt	11,303

[19] Nacatoch 1100 feet, gas; Buckrange 1700, oil; Barlow 2300, gas; Adams 2650, gas; Tiller (Paluxy) 2300 gas; Werner 3600, gas; Jeter (Glen Rose) 5700, gas; Pettit, gas.

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
39	Percilla,[2] *Houston*	1937	10y	200y	{ 800 29,551	800 0 }
40	Pickering, *Shelby*	1941	20	0	948	151
41	Pittsburg, *Camp*	1940	560	0	140,733	93,627
42	Pleasant Grove, *Rusk*	1941	200	0	77,768	59,663
43	Pleasant Grove (shallow), *Rusk*	1941	40	0	10,384	10,384
44	Post Oak (Chilton), *Falls*	1922	1yy	0	178,983	223
45	Potter (Caddo),[15] *Marion*	1905	980	0	7,705,338	25,608
46	Pottsboro, *Grayson*	1928	20	1yyy	11,805	940
47	Powell,[20] *Navarro*	1923	2,600	y	111,740,515	554,028
48	Quitman, *Wood*	1942	400	0	3,080	3,080
49	Red Lake,[2] *Freestone*	1934	10	3yyy	{ 1,815 1,605	83 0 }
50	Richland, *Navarro*	1924	440	y	6,669,210	12,584
51	Rodessa (Dees-Young),[2,15] *Cass*	1935	5,010	3,250	29,800,242[21]	1,697,571[21]
52	Rodessa (Hill-Gloyd),[2,15] *Cass*	1936	1,885	10,150	9,126,419[21]	418,477[21]
53	Rodessa (Hill-Henderson-Gloyd),[2] *Marion*	1937	4,035	10,150	12,496,646[21]	949,026[21]
54	Rodessa,[2,15] Total		10,930	23,550	51,423,307[21]	3,065,074[21]
55	Rowe and Baker, *Henderson*	1939	80	0	82,412	8,468
56	Shelbyville, *Shelby*	1917	50	0	14,911	1,300
57	Sulphur Bluff, *Hopkins*	1936	855	0	9,575,508	1,537,833
58	Talco, *Franklin, Titus*	1936	7,850	0	57,628,610	9,504,827
59	Tehuacana, *Limestone*	1940	60	0	38,140	10,616
60	Tri-Cities,[1] *Henderson*	1941	y	160y	34,188	28,249
61	Trinity, *Houston*	1934	120	0	1,895,908	140,276
62	Van (Deep), *Van Zandt*	1929	4,520	60	132,918,835	3,383,355
63	Van (Shallow), *Van Zandt*	1933	200	0	332,365	20,653
64	Van, total		4,720	60	133,251,200	3,404,008
65	Waskom,[2,15] *Harrison*	1924	1,500	7,280	{ 218,489 104,099	81,951 12,419 }
66	Weiland, *Hunt*	1942	225	0	23,607	23,607
67	Willow Springs,[2] *Gregg*	1938	40	4,500	{ 257,390C 2,065	209,360C 0 }
68	Wortham,[24] *Freestone*	1924	715	0	22,938,931	167,288
69	Total				{ 16,037,666 2,405,795,023y	6,895,129 152,033,152 }

ABANDONED FIELDS

		Year Discovery	Year Abd.				
70	Beulah (Lee-Tex), *Angelina*	1935	1935	10	0	750	0
71	Camp Hill, *Anderson*	1935	1937	200	0	289,030	0
72	Cedar Creek, *Limestone*	1927	1930	30	0	330,600	0
73	Chatfield, *Navarro*	1905	1910	0	150	0	0
74	DeBerry, *Panola*	1926	1932	100	50	29,166y	0
75	Kosse, *Limestone*	1922	1922	10	0	33,000	0
76	Marlin-Satin, *Falls*	1931	1939	10	0	12,830	0
77	Mexia (shallow), *Limestone*	1912	1920y	0	4,094	0	0
78	Mount Calm, *Hill*	1929	1931	x	x	27,991	0
79	Redland, *Angelina*	1939	1940	10	0	60	0
80	Rusk, *Cherokee*	1934	1939	200	0	261,134	0
81	Tacoma, *Panola*	1933	1938	40	0	15,750	0
82	Witherspoon-McKie, *Navarro*	1915	1935	400	0	810,495	0
83	Total, Abandoned Fields					1,810,806	0
84	Grand Total					{ 16,037,666 2,407,605,829y	6,895,129 152,033,152 }

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[20] Includes shallow production discovered and produced since 1923 in the Powell Woodbine producing area.
[21] Production by horizons estimated. Includes distillate production.
[24] Wortham Shallow discovered in 1912 included with Wortham.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operations[d]	Character of Oil	
				During 1942		End of 1942			Number of Wells						
	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
39	807	63	3	1	1	0	0	1	0	0	y y	y y		y 41	
40	x	x	1	0	0	1	0	0	0	0	y	y		40	
41	x	x	6	2	0	1	5	0	2	3	3,408	y		42	
42	x	x	8	3	0	1	7	0	4	3	y	y		40	
43	x	x	1	0	0	0	1	0	0	1	y	y		35	
44	x	x	26y	0	0	1	0	0	0	0	y	y		33	
45	x	x	78y	0	0	2	28	0	0	28	y	y		40	
46	x	x	15	0	0	0	1	0	0	1	300	y		39	
47	x	x	766	2	0	1	149	0	0	149	800	y		38	
48	0	0	1	1	0	0	1	0	1	0	2,742	2,742		42	0.9
49	1,994	49	3	0	0	1	0	2	0	0	2,102	2,005		y	
50	x	x	111	0	0	0	4	0	0	4	y	y		38	
51	y	9,392[8]	298	0	9	41	220	9	24	196	2,700	700		43	
52	y	3,975[8]	89	0	10	19	52	8	18	34	2,700	500	RP	42	
53	y	10,397[8]	181	0	11	19	119	15	47	72	2,677	1,050		42	
54	y	23,764[8]	568	0	30	79	391	32	89	302					
55	x	x	4	0	0	1	2	0	0	2	y	y		32	
56	x	x	2	0	0	0	1	0	0	1	y	y		38	
57	x	x	73	0	0	0	73	0	0	73	1,900	y		23	
58	x	x	821	3	4	14	742	0	5	737	1,920	y		21	
59	x	x	8	0	0	0	3	0	0	3	y	y		21	
60	y	y	1	0	0	0	0	1	0	0	3,650	y		60	
61	y	y	20	0	0	1	15	0	0	15	870	y		24	
62	y	y	582	1	0	3	562[22]	2	334	228	1,230	1,091[23]		34	
63	y	y	39	0	0	0	30	0	0	30	y	y		31	
64	y	y	621	1	0	3	592	2	334	258					
65	114,364	7,407	248	3	11	y	14	75	1	13	y 2,268 2,660	y 2,158 2,535		35 59 59	
66	0	0	6	6	0	0	6	0	4	2	1,242	1,126		36	0.8
67	21,005	16,686	9	1	0	0	0	9	0	0	3,468	2,340	PM	y 57 38	
68	x	x	341	2	0	2	32	0	0	32	y	y		29 37	
69	1,323,369y	328,898y	36,624y	265	437	974y	29,126	445y	17,786	11,340					

ABANDONED FIELDS

Line Number	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942	Repressuring Operations[d]	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
70	0		1		0						200y	x		24.0	
71	y		10y		0						1,950	x		40.6	
72	y		14		0						x	x		37.0	
73	4,750		15		0						250	x		Gas	
74	x		22		0						757	x		46.0	
75	0		1		0						x	x		32.0	
76	0		2		0						x	x		34.2	
77	20,200y		50y		0						276	x		Gas	
78	x		2		0						x	x		31.3	
79	0		1		0						x	x		23 0	
80	0		5		0						x	x		42.0	
81	0		3		0						x	x		46.0	
82	0		85		0						x	x		19.0	
83	24,950		211		0										
84	1,348,319y	328,898y	36,835y	265	437	974y	29,126	445y	17,786	11,340					

[22] Three wells producing from Sub-Clarksville.
[23] Brown sand.

TABLE I.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
39	Woodbine	CreL	S	y	5,932 5,665	5,939 5,670	Gas 6 Oil 5	A	CreL (Del Rio)	6,634
40	Nacatoch	CreU	S	y	1,475	1,510	20	ML	Washita	3,343
41	Travis Peak	CreL	S	16	7,948	8,200	62	A	Travis Peak	8,203
42	Woodbine	CreU	S	20	4,055	4,062	5	f and Shoreline	Woodbine	4,372
43	Nacatoch	CreU	S	y	2,910	2,965	25y	f and Shoreline	Woodbine	4,372
44	Buda	CreL	L	y	1,025	1,046	10	AF	Trinity	3,567
45	Nacatoch Tokio	CreU	S	y 20	1,025 2,300	1,040 2,366	y 15	A	CreU (Tokio)	2,400
46	Trinity (Basal)	CreL	S	y	830	838	8	MU	Ordovician, or older	6,004
47	Woodbine	CreU	S	25	2,925	3,000	40	AF	Trinity	6,506
48	Paluxy	CreL	S	24	6,280	6,544	40	AD	Paluxy	6,544
49	Woodbine	CreU	S	20	4,850	4,950	25	AF	Woodbine	5,002
50	Woodbine	CreU	S	25	2,975	3,040	20	AF	Glen Rose	5,414
51	L. Glen Rose (Dees-Young)	CreL	Ls	17	5,794	6,040	25	AF		
52	L. Glen Rose (Hill, Gloyd)	CreL	S, L	16	5,914	6,000	20	AF		
53	L. Glen Rose (Hill, Henderson, Gloyd)	CreL	S, L	15	6,044	6,094	20	AF	Salt, CreL, or older	11,484
54										
55	Woodbine	CreU	S	20	3,140	3,149	6	AF	Woodbine	3,149
56	Blossom?	CreU	S, L	y	3,196y	3,348y	10	ML	Georgetown	3,520
57	Paluxy	CreL	S	25	4,487	4,523	36	AF	Glen Rose	6,600
58	Paluxy	CreL	S	20	4,200	4,300	35	AF	Salt	9,048
59	Woodbine	CreU	S	y	2,640	2,700	10	AF	Georgetown	2,825
60	L. Glen Rose (Rodessa)	CreL	L	y	7,608	7,641	20	A	Travis Peak	8,474
61	Carrizo	Eoc	S	y	1,987	2,015	25	Ds	Salt-dome material	3,855
62	Woodbine	CreU	S	y	2,682	2,950	268	AF		
63	Nacatoch	CreU	S	y	1,200	1,220	20	AF	Travis Peak	7,501
64										
65	Nacatoch, Blossom Glen Rose Travis Peak	CreU CreL	Ls S L	y 15 12	800	6,160	15–40	AD	Travis Peak	6,490
66	Woodbine	CreU	S	25	2,766	2,780	12	AF	Paluxy	4,411
67	L. Glenn Rose (Rodessa) L. Glen Rose (Pettit) L. Glen Rose (Pettit)	CreL	OL	y y y	6,768 7,244 7,298	6,770 7,268 7,308	Gas 2 Gas 35 Oil 10y	D	Cotton Valley	10,284
68	Nacatoch Woodbine	CreU	S	y 25	1,361 2,990	1,371 3,050	6 35	AF	Glen Rose	4,825
69										
	ABANDONED FIELDS									
70	Queen City	Eoc	S	x	2,045	2,053	5	ML	Carrizo	2,324
71	Sub-Clarksville, (Eagle Ford); Woodbine	CreU	S, SH	y	5,054	5,059	5	AF	L. Glen Rose	8,383
72	Woodbine	CreU	S	25	2.885	2,940	10	AF	Woodbine	3,310
73	Corsicana (Wolf City)	CreU	S	x	880	1,020	13	A	Woodbine	3,057
74	Blossom	CreU	S, H	y	1,990	2,087	y	ML	Blossom	2,125
75	Unknown			x	x	3,767	x	Crev	Glen Rose	6,056
76	Buda	CreL	L	20	1,000	1,160	20	AF	Glen Rose	1,409
77	Nacatoch	CreU	S	25.5	710y	750y	40y	AF	CreL or older	8,845
78	Austin	CreU	C	x	607	700	8	F	Travis Peak	3,398
79	Wilcox	Eoc	S	y	1,021	1,032	8	ML	Wilcox	1,032
80	Woodbine	CreU	S	20	5,120	5,125	10y	MU	Woodbine	5,302
81	Blossom	CreU	S	y	2,073	2,085	10	ML	Blossom	2,302
82	Nacatoch	CreU	S	14	825	875	19	AF	Woodbine	3,480
83										
84										

were totally exempt from the shutdown orders of the Texas Railroad Commission.

The Commission issued several new orders to East Texas field operators in order to curtail the increasing production of salt water, which had caused the reservoir pressure to decline to a low of 1007.87 lb. in March 1942. Among these orders was one dated Feb. 20, 1942, allowing the operators: (1) to transfer or sell their "salt-water bonus" allowables to any other operator or to a salt-water disposal company instead of producing the same on their own leases; (2) to shut in, after March 1, 1942, any wells making more than 100 bbl. of salt water per day, and produce the shut-in allowable from the other well or wells on the same lease or elsewhere, as approved by the Commission, provided the shut-in wells are retested every six months; (3) allocate as much as 6 bbl. "salt-water bonus" allowable to any well not making as much as 25 per cent water.

DISCOVERIES

Amerada Petroleum Company's No. 1 C. B. Kennemer was completed as a discovery well for the Coke field, Wood County. Production was found in the Paluxy sand, the horizon from which the Talco and Sulphur Bluff fields produce. The Delta Drilling Co. and Rube Benton No. 1 J. B. Goldsmith also found Paluxy sand production and opened the Quitman field in the same county.

The Coke and Quitman fields represent the second and third oil discoveries for Wood County, respectively, and the first oil production secured in the county from the Paluxy sand. The only other field in the county, at present, is Hawkins, which produces oil from the Woodbine sand.

TABLE 2.—*Summary of Drilling Operations in East and East Central Texas*

Discoveries, Extensions, and Important Wildcats Drilled during 1942

Line Number	County	Drilled by	Well Number and Farm	Survey	Producing Formation
1	Anderson	Magnolia Petr. Co.	1, C. W. Campbell	J. B. McNeeley	Woodbine
2	Cass	John Messenger	1, Benefield & Singleton	John Wanhope	Gloyd
3	Cherokee	Humble Oil & Ref. Co.	1, H. F. Curtiss	John Vaughn No. 53	Pettit
4		Magnolia Petr. Co.	1, S. E. Braly	Josiah Thomas	
5	Ellis	J. B. Stoddard	1, W. E. Smith	J. B. Edwards	
6	Franklin	R. T. Myers	1, Cox	W. C. Sanford	
7		J. B. White, Grady Vaughn et al,	1, W. H. Jackson	J. E. Hopkins	
8	Freestone	Ohio Oil Co.	1, F. E. Hill, Jr.	T. Du Bronner	
9	Henderson	Delta Drilling & Lone Star Gas Co.	1, W. J. Gentry	C. M. Walters	
10		Texas Company	1, Elva T. Brown	Armstead Eans	
11	Houston	E. A. Gillespie et al.	1, G. T. Lundy	John Forbes	Wilcox
12	Hunt	American Liberty Oil Co.	1, J. P. McNatt	Enos Murphy	
13		Hollandsworth Drilling Co.	1, J. D. Baker	John Warren	Woodbine
14	Limestone	Texas Company	1, W. A. Keeling	A. Whitaker	
15	Morris	Bert Fields	1, P. H. Pewett	B. B. B. & C. No. 426	
16		M. H. Marr	1, Morris Sheppard Est.	B. B. B. & C. No. 319	
17	Navarro	Falcon Oil Co.	1, J. C. Keitt	S. Denton	
18	Shelby	Humble Oil & Ref. Co.	1, R. C. Adams	Wm. Reynolds	
19		E. E. Hurley, Vaughn et al.	1, Frost Lumber Co.	W. M. Waterman	
20		Imperial Petroleum	1, Anna H. Hanson	Stephen English	
21	Smith	Sun Oil Co.	2, Friedlander	John Slaydon	Rodessa
22	Upshur	O. J. Perren	1, Mrs. R. H. McClelland	M. Del Torres	
23	Wood	Amerada Petroleum Corp.	1, C. B. Kennemer	Joseph Knight	Paluxy
24		Delta Drilling Co. & Rube Benton	1, J. B. Goldsmith	S. G. Purse	Paluxy
25		Magnolia Petr. Co.	1, G. A. McCreight	E. Esparza	

The Hollandsworth Drilling Co. discovered the first oil field in Hunt County when No. 1 J. D. Baker produced from the Woodbine sand on the upthrown side of a fault, along the Mexia fault zone in the south central part of the county. This field is now known as Weiland, although it was first called Club Lake.

John Messenger's No. 1 Benefield and Singleton, Cass County, was completed in the "Gloyd" limestone of the Lower Glen Rose as the discovery well for the Kildare field.

Humble Oil and Refining Co. discovered Pettit lime production in No. 1 H. F. Curtiss, to open the Larissa field, Cherokee County, at the deepest producing level in the district.

Magnolia Petroleum Co. completed its No. 1 C. W. Campbell in Anderson County as a discovery well for the Concord field. This well produces 12° gravity oil from the Woodbine sand.

The only important extension during 1942 was to the Chapel Hill field in Smith County.

CONSTRUCTION OF OIL PIPE LINES

The outstanding event in pipe-line construction during the year was the laying of a 24-in. line from Longview, Tex., to Norris City, Ill., by the War Emergency Pipe Lines, Incorporated. As a result of the construction of this line, the Shell, Pan-American, and Sun-Stanolind lines from the Texas Gulf Coast to the East Texas field were in the process of being reversed, and several gathering and transfer lines were being completed in, and near, the East Texas field. Table 5 shows pipe line construction for the year 1942.

TABLE 2.—(*Continued*)

Discoveries, Extensions, and Important Wildcats Drilled during 1942

Line Number	Depth Completed, Ft.	Total Depth, Ft.	Deepest Horizon Tested	Initial Production per Day: Oil, U. S. Bbl.	Initial Production per Day: Gas, Millions Cu. Ft.	Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.: Casing	Pressure, Lb. per Sq. In.: Tubing	Remarks
1	4,522	4,669	Woodbine	201	None	Pump			Discovery well, Concord field
2	5,992	6,205	Dees-Young	186	0.250	¼	1,000	500	Dis. well, Kildare field
3	10,163	10,604	Travis Peak	37	0.065	¼	910	25	Dis. well, Larissa field
4		9,006	Travis Peak						Dry hole, east of Mixon
5		5,020	Quartzite						Dry hole, 1 mile west of Alma
6		6,110	Paluxy						Dry hole, 5 miles north of Winnsboro
7		9,048	Salt						Deep test, Talco field
8		10,115	Pettit						Dry hole, 5 miles north of Butler
9		8,704	Travis Peak						Dry hole, 3 miles southwest of Athens
10		9,965	L. Glen Rose						Dry hole, 8 miles southwest of Chandler
11	3,215	5,016	Wilcox	131		Pump			Dis. well, abandoned account water
12		6,895	Smackover lime						Dry hole, 5 miles west of Greenville
13	2,761	2,779	Woodbine	266	0.013	¼	50	105	Dis. well, Weiland field
14		6,018	Schist						Dry hole, 6 miles southwest Cooledge
15		5,027	Paluxy						Dry hole, 7 miles northwest of Naples
16		4,817	Paluxy						Dry hole, 8 miles north of Naples
17		6,455	Schist						Dry hole, 10 miles west of Currie
18		6,446	L. Glen Rose						Dry hole, slight show oil and gas
19		6,786	L. Glen Rose						Dry hole, 10 miles southwest of Center
20		5,361	L. Glen Rose						Dry hole, 1½ miles northeast Shelbyville, slight spray
21	7,741	8,448	Pettit	102	0.032	9/32	875	70	Dis. well, Rodessa zone, Chapel Hill field
22		5,350	Paluxy						Dry hole, 5 miles southeast of Gilmer
23	6,262	6,384	Paluxy	1,920	0.206	2	225	95	Dis. well, Coke field
24	6,280	6,540	Paluxy	726	0.229	¼	625	590	Dis. well, Quitman field
25		6,665	Glenrose						Dry hole, 4 miles southeast of Yantis

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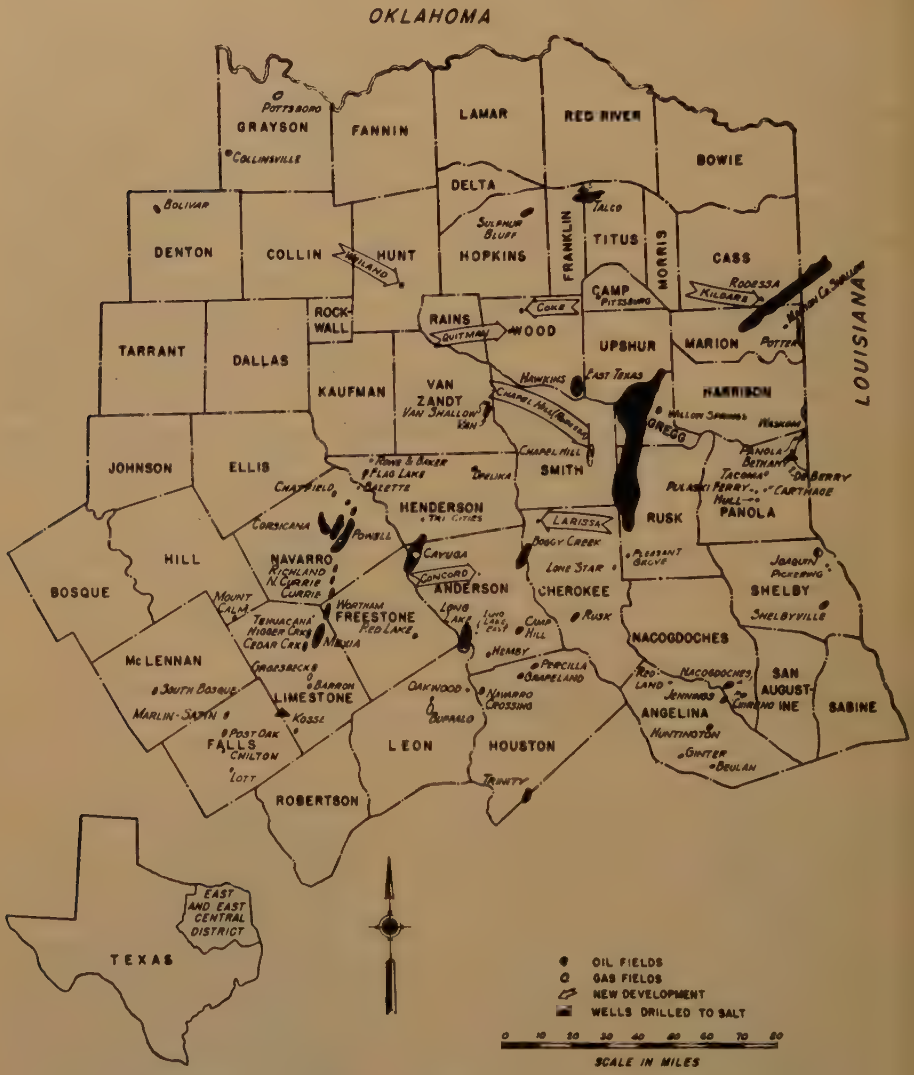

FIG. 1.—LOCATION OF OIL AND GAS FIELDS, EAST AND EAST CENTRAL TEXAS. (Texas Railroad Commission Districts 5 and 6)

Covell, The Pure Oil Co., Fort Worth, Tex.; Mr. Melbert Schwarz, Seaboard Oil Co., Dallas, Tex.; Mr. F. E. Heath, Sun Oil Co., Dallas, Tex.; Mr. E. L. Rawlins, Union Producing Co., Shreveport, La.; Mr. M. A. Andretta, Delta Drilling Co., Tyler, Tex.; Mr. A. L. Selig, Stanolind Oil and Gas Co., Houston, Tex.; Mr. J. S. Noland, Barnsdall Oil Co., Tulsa, Okla.; Mr. L. A. Hancock, Magnolia Pipe Line Co., Greggton, Tex.

They wish also to thank the following employees of the Magnolia Petroleum Co. for assistance: Messrs. C. A. Awalt, Dan C. Williams, Jr., Lester T. Daniel, M. S. Priddy and Capt. J. A. Walker.

TABLE 3.—*Production Statistics, East Texas Field*[a]

Date, Year 1942	Average Reservoir Pressure at −3300 Ft., Lb. per Sq. In.	Production, Bbl. (42 U. S. Gal.)	Number of Days Shut Down
Jan. 1	1,025.58	12,196,925	7
Feb. 1	1,009.73	10,707,223	7
Mar. 1	1,007.87	9,264,244	13
Apr. 1	1,027.12	6,300,215	18
May 1	1,049.75	9,735,730	12
June 1	1,031.51	9,219,156	12
July 1	1,038.49	8,736,873	14
Aug. 1	1,037.71	11,130,365	9
Sept. 1	1,020.44	10,633,415	9
Oct. 1	1,020.71	11,108,121	9
Nov. 1	1,015.22	10,592,714	9
Dec. 1	1,017.12	11,055,614	9
	Average 1,025.10	120,680,595	128

[a] Data from Texas Railroad Commission.

TABLE 4.—*Oil-recovery Data on Older Woodbine Fields as of January* 1, 1943

Field	County	Cumulative Production, Bbl.	Proved Acres	Net Thickness, Ft.	Acre-feet	Cumulative Production, Bbl. per Acre-foot
Boggy Creek	Anderson, Cherokee	5,112,383	960	34	32,640	157
Cayuga	Anderson, Freestone, Henderson	25,774,230	9,700	18	174,600	148
Currie	Navarro	6,940,687	475	20	9,500	731
East Texas	Cherokee, Gregg, Rusk, Smith, Upshur	1,831,943,446	136,000	35	4,760,000	385
Flag Lake	Henderson	539,730	405	5	2,025	266
Mexia	Limestone	98,390,061	3,920	50	196,000	502
Nigger Creek	Limestone	2,999,466	170	15	2,550	1,176
Powell	Navarro	111,740,515	2,600	40	104,000	1,074
Richland	Navarro	6,669,210	440	20	8,800	758
Van (deep)	Van Zandt	132,918,835	4,520	268	1,211,360	110
Wortham	Freestone	22,938,931	715	35	25,025	917
Cedar Creek[a]	Limestone	330,600	30	10	300	1,102
Rusk[a]	Cherokee	261,134	200	10	2,000	131

[a] Abandoned fields.

TABLE 5.—*Pipe Lines in Texas during* 1942

Company	From	To	Length, Miles	Size, In.	Status
Construction of Pipe Lines					
R. Lacy P. L. Co.	Hawkins	Gladewater	15½	4	Completed
Sinclair Ref. Co.	Chapel Hill	East Texas field	8	4	Completed
War Emergency P. L. Inc.	Longview	Norris City	530	24	Completing
Pipe Lines Taken Up					
American Liberty	East Texas field	Houston	200	8	
Humble P. L. Co.	Van	Hawkins	25	10	
Texas P. L. Co.	East Texas field	Douglas	38¾	10	
Texas P. L. Co.	Douglass	Port Arthur	96	8	
Texas P. L. Co.	Oil City, La.	San Augustine	78½	8	
			21¼	6	

Oil and Gas Production in the Texas Gulf Coast during 1942

By P. B. Leavenworth,[*] Member A.I.M.E., and W. H. Hough[*]

Development during 1942 led to the discovery of 26 new fields in the Texas Gulf Coast, as compared with 27 during 1941. Of these, 19 are classed as oil fields, 4 distillate fields, and 3 gas fields. Production from the new fields amounted to 614,467 bbl. to October 1942.

Producing Sections.—Discoveries in 1942, compared with the previous two years, classified by producing formations, are shown in the following table:

Year	Miocene	Frio	Jackson	Yegua	Cook Mountain	Wilcox
1940	2	15	1	2	1	4
1941	5	10	2	4		6
1942	1	9	1	4		11

It is interesting to note the increase in Wilcox discoveries due to the extensive geophysical campaign that has been conducted since 1940.

Drilling.—During the year 688 wells were drilled, of which 574 produced oil or gas and 114 were dry. This represents a considerable decline in activity over the previous year, when 1405 wells were drilled in the area, of which 1081 were producers and 324 failures. Jackson County continued to hold the lead, with 222 wells completed.

Production.—Despite curtailed drilling, production amounted to 118,009,451 bbl. for 1942, indicating a slight increase over the 113,726,893 bbl. produced during 1941. The statistics in Tables 1 and 2 include condensate and distillate as oil production, because many Gulf Coast fields produce oils with a wide variation of specific gravities, all of which are commingled in pipe lines.

Table 3 shows by counties most of the activities referred to. The number of wells drilled includes only field wells; not wildcats.

Outstanding Fields of 1942

The Texas Gulf Coast covered in this report has 270 more or less active oil and gas fields, including the new discoveries of 1942. Of these the most outstanding from the standpoint of production are listed in Table 4. Each of these fields produced one million barrels or more during 1942. Some of the fields where new extensions are occasionally referred to as separate fields, such as West Columbia and New West Columbia, or Thompson and South Thompson, are combined to give a more accurate outline. Two interesting facts may be noted from this list of some 26 oil fields: (1) that the Lolita field, Jackson County, is the only discovery since 1938 to produce more than one million barrels annually, although there have been 79 discoveries since Jan. 1, 1940; (2) that 20 of these 26 fields produce from the Frio.

New Fields

Alief, Harris County.—Pure Oil Company's No. 1 Mike Albanese was drilled to 8637 ft. in Cook Mountain shale. After numerous tests the well was completed on Apr. 20, 1942, in a Yegua sand at 7919 to 7924 ft. for 54 bbl. of 52° gravity oil and 3,335,000 cu. ft. of gas through

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[*] Gulf Oil Corporation, Houston, Texas.

TABLE 1.—*Oil and Gas Production in the Texas Gulf Coast*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942
1	Aldine, *Harris*	1939	50	0	60,708	14,902	*y*	*y*
2	Alief, *Harris*	1942	40					
3	Allen, *Brazoria*	1927	10	0	90,832	0	0	0
4	Alta Loma, *Galveston*	1940	205	0	487,584	75,271	*y*	*y*
5	Amelia, *Jefferson*	1936	1,000	*y*	7,107,538	1,380,083	*y*	*y*
6	Anahuac, *Chambers*	1935	7,000	*y*	23,669,051	3,587,642	*y*	*y*
7	Angleton, *Brazoria*	1939	700	0	567,206	75,441	0	0
8	Aransas Pass (McCampbell), *Aransas*	1936	2,340	*y*	11,315,650	626,031	*y*	*y*
9	Armour, *Matagorda*	1938	125	*y*	168,739	17,577	0	0
10	Arriola, *Hardin*	1932	100	*y*	2,327,775	94,796	0	0
11	Baileys Prairie, *Brazoria*	1940	40	40	200	*y*	Shut in	
12	Bammel, *Harris*	1936	2,200	*y*	523,618	40,059	*y*	*y*
	Barbers Hill, *Chambers:*							
13	2300-ft.	1916	500±	0	76,866,216	2,861,740	0	0
14	5200-ft.	1928						
	Batson, Hardin:							
15	Shallow, 350–2600 ft.	1903	500	0	39,469,373	148,190	*y*	*y*
16	Deep, 4600–5650 ft.	1934	150	0	2,289,500	106,554	*y*	*y*
17	Bay City, *Matagorda*	1934	1,240	*y*	5,258,677	594,314	0	0
18	Beeville (Church), *Bee*	1935	20	*y*	1,000	0	*y*	0
19	Berclair, *Bee*		*y*	*y*	*y*	*y*	*y*	*y*
20	Big Creek, *Ft. Bend*	1922	240	*y*	10,140,306	103,228	0	0
21	Big Hill, *Jefferson*	1923	10	40	14,000	*x*	*y*	*y*
22	Big Hill (Gulf), *Matagorda*	1904	35	5	211,000	*y*	*y*	0
23	Bland, *Orange*, included with Orange							
24	Blessings, *Matagorda*	1940	2,000	*y*	22,918	*y*	*y*	*y*
25	Blue Ridge, *Fort Bend*	1919	400	*y*	11,358,327	300,640	0	0
26	Boling, *Fort Bend-Wharton*	1925	250	0	7,959,062	345,345	0	0
27	Bonnieview, *Refugio*	1939			Changed to La Rosa			
28	Borden, *Abel*, *Wharton*	1940	40	*y*	44,494	6,663	0	0
29	Brenham, *Washington*, *Austin*	1926	50	0	333,622	2,505	0	0
30	Brookshire, *Waller*	1934	50	*y*	21,882	*y*	0	0
31	Brushy Creek, *Lavaca*	1941	80	*y*	*y*	*y*	*y*	*y*
32	Buckeye, *Matagorda*	1932	115	*y*	831,256	18,076	*y*	*y*
33	Burnell, *Karnes*		20	60	1,118	0	0	0
34	Burnell (South), *Karnes*	1937	395	*y*	1,015,173	40,826	*y*	*y*
35	Bucksnag, *Colorado*	1942	40	0	637	637	0	0
36	Buttermilk Slough, *Matagorda*	1939	50	0	10,491	926	0	0
37	Cadiz, *Bee*	1942	0	80	Shut in		*y*	*y*
38	Caesar, *Bee*	1934	520	*y*	1,070,676	28,222	*y*	*y*
39	Call, *Newton*	1937	100	0	11,500	484	0	0
40	Camp Eleven, *Tyler*	1942	80	0	73,906	73,906	0	0
	Caplen, *Galveston:*							
41	Deep	1939	430	80	507,019	187,959	*y*	*y*
42	Shallow	1940	0	40	0	0	*y*	*y*
43	Cedar Bayou, *Chambers*	1938			22,610	5,213	*y*	*y*
	Cedar Point, *Chambers:*							
44	Shallow	1938	80	0	1,261,692	190,126	0	0
45	Deep	1938	400	*y*			0	0
46	Cheek (North), *Jefferson*	1937	60	0	68,979	*y*	0	0
47	Chenango, *Brazoria*	1941	120	*y*	57,765	21,533	*y*	*y*
48	Chiesman, *Burleson*	1938	*y*	0	14,429	*y*	0	0
49	Chocolate Bayou, *Brazoria*	1939	500	4	272,813	112,495	*y*	*y*
50	Cistern Gas, *Fayette*	1942	0	40	0	0	Shut in	
51	Clam Lake, *Jefferson*	1937	500	0	421,857	110,944	0	0
52	Clay Creek, *Washington*	1927	300	*y*	4,744,763	141,154	*y*	*y*
53	Clear Lake, *Harris*	1938	2,100	*y*	523,618	40,059	*y*	*y*

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[b] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE 1.—(*Continued*)

Line Number	Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
	Completed to End of 1942	During 1942		End of 1942			Number of Wells						
		Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
1	2	0	y	y	1	0	1	0	x	y		37–66	y
2	1	1	0	0	1	0	1	0			0	52	y
3	2	0	0	0	0	0	0	0	200	x	0	y	y
4	6	2	0	0	6	0	6	0	y	y	0	34–38	y
5	115	0	y	y	105	0	105	y	925	y	0	27–29	y
6	389	2	y	0	359	13	359	y	3,260	y	0	34.5	y
7	8	0	0	0	8	0	8	0	x	x	0	50	y
8	342	0	y	y	196	2y	81	117	2,220	x	y	47	y
9	3	0	0	y	3	0	1	2	2,000	y	0	33–37	y
10	21	0	y	y	12	0	0	12	x	y	y	30–34	y
11	2	2	0	0	1	1	2	0	y	y	0	46.4	y
12	20	0	0	y	1	0	1	0	x	y	y	58	y
13	426	3	y	y	144	0	23	121	x	y	y	25–29	y
14									296	y	y	27	y
15	1,019	0	0	y	154	0	0	154	x	y	0	24–38	y
16	Incl. above	2	2	y	8	0	1	7	296y	y	0	Included above	y
17	59	1	y	y	53	0	52	1	y	y	0	35–36	0.087
18	1	0	0	0	0	0	0	0	y	y	0	61.7	y
19	1	1	0	1	0	0	0	0	y	y		54.5–56.5	y
20	91	1	y	y	17	0	0	17	400	y	0	20–42	y
21	6	2	2	0	y	1	1	y	x	x	0	20–42	y
22	8	0	0	y	0	0	0	0	x	x	0	x	x
23													
24	7	0	0	0	7	y	7	0	y	y	0	56	y
25	218	3	y	y	45	0	7	38	Variable	x	0	21–38	y
26	242	7	y	y	54	0	18	36	y	y	0	19–33	y
27											Changed to La Rosa		
28	1	0	0	0	1	0	1	0	y	y	0	35.6	y
29	37	0	y	y	6	0	0	6	x	y	0	14–19	y
30	1	0	0	0	1	0	1	0	100	y	0	23	y
31	2	1	0	0	2	0	2	0	y	y	0	54.6–57.5	y
32	4	1	0	0	4	0	1	3	1,045	y	0	36.8–39	y
33	8	0	y	y	0	0	0	0	y	y		y	y
34	34	2y	y	y	25	y	24	1	y	y	0	47	y
35	1	1	0	0	1	0	1	0	y	y	0	50.2	y
36	1	0	0	0	1	0	1	0	1,140	y	0	45	y
37	2	2	0	0	0	2	Shut in 2	0	y	y	0		
38	42	y	y	y	16	y	0	16	315	y	y	33	y
39	1	0	0	0	1	0	y	y	1,475	y	0	39.3	y
40	2	2	0	0	2	0	2	0	y	y	0	44.8–46.2	y
41	20	2	0	0	17	2	19	0	3,300	2,866y	0	30.3–50.3	y
42	1	0	0	0	0	1	1	0	y	y	0		
43		0			1		1						
44	2	0	0	0	16	0	16	0	y	y	0	28.2–31	y
45	15	0	0	0					2,750	y	0	36–38	y
46	3	0	y	y	y	0	y	y	y	y	0	43.9–60.5	y
47	3	1	y	y	1	0	1	0	y	y	0	31y	y
48	1	0	y	y	y	0	y	y	y	y	0	34.3	y
49	4	1	y	y	2	0	2	0	x	x	0	38–57	y
50	1	1	0	0	0	1	1	0	1,000	y	0	Gas	
51	15	0	y	y	12	0	10	2	y	y	0	22.3–44	y
52	69	0	y	y	50	y	5	45	x	x	0	22–27	y
53	62	0	y	y	41	4y	40	1	650	y	0	26–31	y

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
1	Yegua	Eoc	S	34	6,622	6,634	10	D	Cook Mountain	7,695
2	Yegua	Eoc	S	Por	7,919	7,924	25	*x*	Cook Mountain	8,637
3	Miocene	Mio	S	Por	4,362	5,139		DS	Miocene	5,958
4	Marine Frio (Hackberry)	Olig	S	Por	9,160	9,184	18	D	Marine Frio (Hackberry)	11,117
5	Frio	Olig	S	Por	6,778	6,791	10	DF	Vicksburg	7,882
6	Frio	Olig	S	27	7,145	7,600	60	DF	Frio	8,749
7	Frio	Olig	S	Por	10,000	10,500	6	D	Frio	11,451
8	Marginulina, Frio	Olig	S	Por	6,544	7,461	20	DF	Frio	8,889
9	Marginulina, Frio	Olig	S	Por	6,614	6,624	4	N	Frio	7,531
10	Miocene, Frio	Mio, Olig	S	Por	3,000	4,700	50±	DS	Vicksburg	6,743
11	Frio	Olig	S	Por	10,535	11,651	4–20	*x*	Frio	11,860
12	Cockfield	Eoc	S	Por	6,170	6,211	10	DF	Wilcox	10,574
13	Cap rock, Mio, Olig	Mio, Olig	S	Por	800	7,200	80–100	DS	Jackson	8,150
14	Frio	Olig	S	30	3,450	6,690	10–80	DS	Jackson	8,184
15	Super Cap, Mio, Olig	Mio, Olig	S	Por	245	3,900	*y*	DS	Included below	
16	Yegua, Cook Mt.	Eoc	S	Por	4,600	5,642	30	DS	Cook Mountain	6,828
17	Marginulina, Frio	Olig	S	27	7,023	8,261	*y*	DF	Vicksburg	11,465
18	Cockfield	Eoc	S	Por	4,825	5,833	7	F	Yegua	6,013
19	Wilcox	Eoc	S	Por	10,020	10,404	*y*	*y*	Wilcox	10,561
20	Pli, Mio, Marg, Frio	Pli, Mio, Olig	S	Por	800	4,528	21	DS	Cook Mountain	8,273
21	Cap rock, Mio, Frio	Mio, Olig	Cavity S	Por	1,700 8,705	8,720 5,958	15 10–50	DS	Marine Frio (Hackberry)	10,186
22	Cap rock, Mio	Mio	Cav S	Por	*y* 862	*y* *y*	*y*	DS	*y*	4,586
23										
24	Frio	Olig	S	Por	8,290	8,300	15	DF	Frio	8,525
25	Mio, Frio	Mio, Olig	S	30	1,956	4,650	55	DS	Yegua	5,280
26	Cap rock, Mio, Frio	Mio, Olig	Cav S	Por	377	5,615	15–60	DS	Vicksburg	6,281
27				Changed to La Rosa						
28	Frio	Olig	S	Por	4,758	4,771	*y*	*x*	Frio	6,557
29	Miocene	Mio	S	Por	183	1,450	*y*	DS	Wilcox	5,039
30	Frio	Olig	S	Por	2,966	2,976	16	*x*	Yegua	7,200
31	Wilcox	Eoc	S	Por	7,680	7,725	55	*x*	Wilcox	10,998
32	Frio	Olig	S	Por	7,761	8,139	60	DF	Frio	10,503
33	Cockfield	Eoc	S	Por	3,280	3,500	20	DF		4,020
34	Cockfield	Eoc	S	Por	3,598	3,674	12	DF	Cook Mountain	5,280
35	Yegua	Eoc	S	Por	6,143	6,145	*y*		Yegua	6,997
36	Frio	Olig	S	20	7,850	7,860	10	DF	Frio	9,582
37	Jackson	Eoc	SH	Por	3,734	3,763	5*y*	*y*	Yegua	4,821
38	Cockfield	Eoc	S	Por	3,070	3,089	15	DF	Yegua	4,230
39	Cockfield	Eoc	S	Por	6,908	6,918	10	DF	Yegua	7,700
40	Wilcox	Eoc	S	Por	7,797	8,010	10*y*	*x*	Wilcox	8,206
41	Mio, Olig	Mio, Olig	S	Por	5,975	7,478	10–40	DS	Oligocene	8,206
42	Mio	Mio	S	Por	3,932	3,938	6*y*	DS	Oligocene	8,206
43										
44	Miocene	Mio	S	Por	4,413	4,478	20		Vicksburg	8,507
45	Frio	Olig	S	35	5,943	6,005	62	D	Vicksburg	8,507
46	Frio	Olig	S	Por	8,326	8,682	10–20	F	Oligocene	9,007
47	Marine Frio (Hackberry)	Olig	S	Por	8,564	10,020	10	DF	Marine Frio	10,497
48	Edwards	Cre	LS	Por	6,168	6,173	5	F	Edwards	6,173
49	Marine Frio	Olig	S	Por	9,660	11,468	16–50	DF	Marine Frio	12,505
50	Wilcox	Eoc	S	Por	2,808	2,814	6*y*		Midway	4,340
51	Miocene	Mio	S	Por	2,387	5,949	5 to 25	DS	Frio (7675–8156)	8,198
52	Mio, Cockfield, Wilcox	Mio, Eoc	SH	Por	1,124	1,500	120	DS	Wilcox	8,306
53	Frio	Olig	S	25	5,790	5,979	40	DF	Frio	7,210

TABLE 1.—(*Continued*)

Line Number	Field, County	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942
54	Cleveland, *Liberty*	1933	700	*y*	1,405,960	83,307	*y*	Shut in
55	Clinton, *Harris*	1936	150	100	309,505	42,673	*y*	*y*
56	Clodine, *Fort Bend*	1941	700	0	213,099	176,650	*y*	*y*
57	Colletto Creek, *Victoria*	1934	260	520	1,537,121	165,614	*y*	*y*
58	Collegeport (Citrus Grove), *Matagorda*	1939	0	3,896	0	0	*y*	*y*
59	Collier, *Jackson*	1942	40	0	*y*	*y*	0	0
60	Cologne, *Victoria*	1939	180	200	114,059	165,614	*y*	*y*
61	Coloma Creek, *Calhoun*	1941	80	0	43,280	21,963	0	0
62	Conroe, *Montgomery*	1931	17,660	*y*	142,076,646	13,507,599	*y*	*y*
63	Cordele, *Jackson*	1938	420	850	2,354,018	326,671	*y*	*y*
64	Cotton Lake, *Chambers*	1937	175	*y*	842,931	81,487	*y*	*y*
65	South, *Chambers*	1936	1,000	*y*	2,790,699	570,043	*y*	*y*
66	Damon Mound, *Brazoria*	1915	250	0	9,537,566	76,466	*y*	*y*
67	Danbury, *Brazoria*	1929	160	*y*	767,864	220,627	*y*	*y*
68	Diamond Half, *Goliad*	1936	240	0	629,364	18,260	0	0
69	Dickinson, *Galveston*	1934	2,700	*y*	7,374,857	600,149	*y*	*y*
70	Dinero, *Live Oak*	1935	350	*y*	95,593	*y*	*y*	*y*
71	Dirks, *Bee*	1934	865	0	6,139,222	144,026	*y*	*y*
72	Duck Bay (Jay Welder), *Calhoun*	1940	*y*	*y*	90,502	44,845	*y*	*y*
73	Dyersdale, *Harris*	1940	1,100	*y*	782,449	421,955	*y*	*y*
74	East Bernard, *Wharton*	1940	100	*y*	1,160	0	*y*	*y*
75	East Placedo, *Victoria*	1937	500*y*	20*y*	586,671	98,899	*y*	*y*
76	Edna, *Jackson*	1937	120*y*	420	4,493	*y*	*y*	*y*
77	Edwards Ranch, *Victoria*	1940	0	80	*y*	*y*	*y*	*y*
78	Esperson, *Liberty*	1929	1,400	*y*	8,470,880	908,132	*y*	*y*
79	South, *Liberty*	1939					*y*	*y*
80	Eureka, *Harris*	1935	900	*y*	3,201,349	430,450	*y*	*y*
81	Fagan, *Refugio*	1940	50*y*	20*y*	198,759*y*	43,017*y*	*y*	*y*
82	Fairbanks, *Harris*	1938	4,000	*y*	11,133,353	2,645,881	*y*	*y*
	Fannette, *Jefferson:*							
83	Shallow	1926	500	0	3,613,193	441,083	*y*	*y*
84	Deep	1940	385*y*	20			*y*	*y*
85	Fannin, *Goliad*	1939	0	80	0	0	*y*	*y*
86	Fig Ridge, *Chambers*	1940	1,280	*y*	278,109	225,318	*y*	*y*
87	Fishers Reef, *Chambers*	1940	100	*y*	58,220	29,128	*y*	*y*
88	Ft. Merrill, *Live Oak*	1935	20	0	65,359	*y*	0	0
89	Fostoria, *Montgomery*	1941	40	*y*	7,273	7,273	*y*	*y*
90	Francitas, *Jackson*	1938	500	*y*	323,334	65,584	*y*	*y*
91	Fred, *Tyler*	1941	180	*y*	50,701	30,725	*y*	*y*
92	Ganado, *Jackson*	1937	1,500	*y*	553,765	297,781	*y*	*y*
93	Garwood, *Colorado*	1933	275	0	6,198	*y*	0	0
94	Genevieve, *Bee*	1941	20	0	1,249	0	0	0
95	Georgewest, *Live Oak*	1940	0	20	0	0	*y*	*y*
96	Gillock, *Galveston*	1936	2,250	*y*	7,672,812	1,171,950	*y*	*y*
97	Goodrich, *Polk*	1941	80	*y*	36,179	31,982	*y*	*y*
98	Goose Creek, *Harris*	1912	1,200	*y*	77,790,474	489,089	*y*	*y*
99	Greens Lake, *Galveston*	1936	225	*y*	102,098	15,479	*y*	*y*
100	Greta, *Refugio*	1933	4,240	*y*	29,443,014	1,173,316	*y*	*y*
101	Halls Bayou, *Brazoria*	1941	20	0	0	0	0	0
102	Hamman, *Matagorda*	1936	1,100	*y*	3,592,185	525,425	*y*	*y*
103	Hampton, *Hardin*	1942	40	0	14,469	14,469	*y*	*y*
104	Hankamer, *Liberty*	1929	400	*y*	6,403,599	196,580	*y*	*y*
105	Hardin, *Liberty*	1935	2,750	*y*	8,476,532	1,067,318	*y*	*y*
106	Harmon, *Jackson*	1942	500		111,533	111,533	*y*	*y*
107	Hartzendorf, *Bee*	1935	*y*	*y*	*y*	*y*	*y*	*y*
108	Hastings, *Brazoria*	1934	5,800	*y*	45,704,215	10,431,616	*y*	*y*
109	Hawkinsville, *Matagorda*	1936	*y*	*y*	2,000	0	0	0
110	Heyser, *Calhoun-Victoria*	1936	5,500	3,620	17,164,014	2,926,870	*y*	*y*
111	High Island, *Galveston*	1922	320	*y*	18,993,432	877,984	*y*	*y*
112	Hillje, *Wharton*	1939	750	*y*	500,088	191,679	*y*	*y*
113	Hitchcock, *Galveston*	1936	200	*y*	1,050,129	152,111	*y*	*y*
114	Hockley, *Harris*	1932	10	0	23,511	0	*y*	*y*

TABLE 1.—(*Continued*)

Line Number	Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure. Lb. per Sq. In.		Repressuring Operation^d	Character of Oil	
	Completed to End of 1942	During 1942		End of 1942			Number of Wells		Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
		Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift					
54	21	0	3	0	9	5	2	7	2,400	x	0	40	y
55	16	0	y	y	7	y	5	2	4,800	x	0	22–48	y
56	13	6	0	0	13	0	13	0	y	y	0	41–51	y
57	50	0	y	y	34	y	27	7	x	x	0	y	y
58	7	4	0	0	0	7	7	0	y	y	0	Gas	
59	1	1	0	0	1	0	1	0	y	y	0	24	
60	16	4	y	y	9	y	9	0	1,100	x	0	24.5–25.3	y
61	2	0	0	0	2	0	2	0	y	y	0	50–54	y
62	991	1	y	y	933	y	861	72	2,275	y	0	35–40	y
63	50	0	y	y	44	y	30	14	340	y	y	22	y
64	12	0	y	y	8	0	2	6	x	y	y	29.6	y
65	54	0	y	y	43	y	23	20	1,050	y	y	30–42	y
66	131	0	0	y	27	0	0	27	x	x	0	21–33	y
67	21	0	0	y	16	0	5	11	500	y	0	22–28	y
68	22	0	y	y	9	0	0	9	x	x	0	47	y
69	127	0	y	y	79	14y	56	23	1,250	y	0	37.5	y
70	4	0	y	y	y	y	0	0	1,600	y	0	43	y
71	101y	0	y	y	86	y	2	84	1,000	y	y	44	y
72	4	0	y	y	4	y	4	0	y	y	y	37–39.2	y
73	52	7	y	y	46	y	40	6	y	y	0	22.3	y
74	1	0	0	0	0	0	0	0	y	y	0	55	y
75	30	10	y	y	24	y	23	1	1,080	y	0	38.5	y
76	15	1	y	y	6	9	15	0	x	y	0	y	y
77	2	0	0	y	0	2	y	0	y	y	0	Gas	x
78	115	12	y	y	85	y	47	38	y	y	0	30–41	0.02
79									y	y	0	21–35	
80	39	0	y	y	26	y	11	15	y	y	0	37–51	y
81	8	3	y	y	5	2	7	0	y	y	0	30.8–38.8	y
82	309	0	y	y	292	y	278	14	3,000	y	y	38.8	y
83	66	1	y	y	36	y	25	11	540	y	0	26–38	y
84									y	y	0	26–38	y
85	1	0	0	0	0	1	1	0	y	y		Gas	x
86	24	18	0	0	24	y	24	0	y	y	0	32	y
87	2	0	0	0	2	0	2	0	y	y	0	32.6	y
88	2	0	0	0	0	0	0	0	1,100	y	0	y	y
89	1	0	0	0	1	0	0	1	y	y	0	39	y
90	10	4	y	y	10	y	10	0	2,450	y	0	48	y
91	2	1	0	0	2	0	2	0	y	x	0	39.6	y
92	41	18	y	y	36y	y	30y	6	2,252	y	0	26	y
93	5	0	y	y	0	0	0	0	y	y	0	43–44	y
94	1	0	0	0	0	0	0	0	y	y	0	54	y
95	1	0	y	y	0	0	0	0	y	y	0	y	x
96	98y	3	y	y	92	y	74	18	1,250	y	y	37.5	y
97	3	1	0	0	3	0	2	1	y	y	0	32.2	y
98	914	2	y	y	83	0	0	83	y	y	0	20–36	y
99	11	0	y	y	1	0	1	0	1,300	y	0	22–52	y
100	y	6	y	y	200		154	46	1,350	y	y	23.2–34.9	y
101	1	0	0	1	0	0	0	0	y	y	0	47.5	y
102	30	0	y	y	23	y	7	16	800	y	0	37	y
103	2	2	1	0	1	0	1	0	y	y	0	40.4	y
104	50	0	y	y	36	y	8	28	424	y	0	18–32	y
105	175	0	y	y	146	y	90	56	900	y	0	37–56	y
106	11	11	1	0	10	(Dual)1	10	0	y	y	0	28.8–29.9	y
107	1	0	0	0	y	0	y	y	y	y	0	45	y
108	693	0	0		683	0	667	16	2,740	y	0	30–33	y
109	1	0	0	0	0	0	0	0	200	x	0	y	y
110	277	0	y	y	237	y	209	28	880	y	0	32.3	y
111	139	0	y	y	56	y	16	40	y	y	0	31.5	y
112	18	1	y	y	15	y	12	3	y	y	0	25	y
113	14	0	y	y	14	y	10	4	800	y	0	29–31	y
114	4	0	0	0	0	0	0	0	40	y	0	22	x

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
54	Cockfield, Wilcox	Eoc	S	15	5,672	9,100	8	DF	Wilcox	10,075
55	Mio, Cockfield	Mio, Eoc	S	Por	3,207	8,102	20	DF	Yegua	8,763
56	Yegua	Eoc	S	Por	7,463	7,505	10	D	Cook Mountain	8,300
57	Miocene, Frio	Mio, Olig	S	Por	2,861	2,880	10	DF	Yegua	7,860
58	Miocene	Mio	S	Por	3,750	4,125	15	D	Basal Miocene	5,813
59	Miocene	Mio	S	Por	2,435	2,455	20		Oligocene	3,707
60	Mio, Frio	Mio, Olig	S	Por	2,825	4,832	5–25	DF	Vicksburg	5,168
61	Miocene	Mio	S	Por	5,891	5,892	*y*	DF	Oligocene	8,514
62	Cockfield, Yegua	Eoc	S	27	5,000	5,250	30	DF	Wilcox	9,040
63	Miocene	Mio	S	Por	2,654	2,753	15	DF	Vicksburg	5,177
64	Frio	Olig	S	Por	6,277	6,345	10	D	Vicksburg	8,580
65	Marginulina, Frio	Olig	S	Por	6,409	6,531		DF	Frio	7,007
66	Miocene, Frio	Mio, Olig	S	Por	1,406	3,800	43	DS	Vicksburg	7,903
67	Mio, Frio	Mio, Olig	S	Por	1,599	7,168	12	DS	Frio	9,190
68	Cockfield	Eoc	S	Por	3,680	3,880	14	DF	Yegua	4,540
69	Frio	Olig	S	Por	7,800	9,142	20	DF	Frio	9,463
70	Yegua	Eoc	S	Por	5,200	5,220	7	D	Cook Mtn.	5,913
71	Cockfield	Eoc	S	Por	3,819	3,990	16	DF	Yegua	4,776
72	Miocene	Mio	S	Por	5,654	5,661	1	*x*	Frio	10,002
73	Miocene	Mio	S	Por	4,050	4,083	10	DF	Yegua	8,515
74	Cook Mountain	Eoc	S	Por	8,070	8,090	10	*x*	Cook Mountain	8,461
75	Frio	Olig	S	Por	4,723	6,867	2–15	AF	Vicksburg	7,502
76	Mio, Frio, Vicksburg	Mio, Olig	S	Por	2,646	5,370	10–50	D	Cockfield	7,180
77	Frio	Olig	S	Por	5,030	5,041	5	*x*	Vicksburg	6,265
78	Miocene, Oligocene	Mio, Olig	S	Por	2,275	*y*	*y*	DS	Cook Mountain	9,734
79	Yegua, Cook Mt.	Eoc	S	Por	7,341	8,900	15	DS	Cook Mountain	9,734
80	Yegua	Eoc	S	Por	7,662	8,094	25	DF	Cook Mountain	9,038
81	Miocene, Frio	Mio, Olig	S	Por	2,118 5,620	2,762 5,900	10 25	DF	Oligocene	7,200
82	Yegua	Eoc	S	Por	6,505	7,185	20	AF	Cook Mountain	7,940
83	Mio, Olig	Mio, Olig	S	Por	3,250		20	DS	Frio	10,595
84	Oligocene	Olig	S	Por	7,800	8,300	*y*	DS	Frio	10,595
85	Miocene	Mio	S	Por	2,855	2,860	5	D	Frio	3,512
86	Frio	Olig	S	Por	8,214	8,600	60	DF	Frio	9,021
87	Frio	Olig	S	Por	8,962	8,964	2	D	Frio	9,952
88	Yegua	Eoc	S	Por	4,643	4,706	5	D	Cook Mountain	5,124
89	Cockfield	Eoc	S	Por	5,790	5,794	4	*x*	Wilcox	11,794
90	Frio	Olig	S	Por	7,380	7,950	15	D	Frio	9,030
91	Wilcox	Eoc	S	Por	8,180	8,200	15	DF	Wilcox	8,500
92	Frio	Olig	S	Por	5,100	6,628	15±	DF	Oligocene	7,635
93	Frio, Yegua	Olig, Eoc	S	Por 12.8	4,021 5,900	4,052 6,203	30 15	DF	Wilcox	10,536
94	Cockfield	Eoc	S	Por	4,160	4,178	18	*x*	Cockfield	4,187
95	Wilcox	Eoc	S	Por	8,340	8,346	6	*x*	Wilcox	8,386
96	Frio	Olig	S	Por	8,300	8,800	12	DF	Frio	9,463
97	Cockfield	Eoc	S	Por	4,030	4,034	4	DF	Wilcox	9,966
98	Pli, Mio, Olig	Pli, Mio, Olig	S	Por	1,000	5,894	40	D	Jackson	6,967
99	Pli, Mio	Pli, Mio	S	20–25	2,712	6,450	10	DS	Oligocene	9,636
100	Mio, Heterostegina, Frio	Mio, Olig	S	20–33	2,000	3,500	20	A	Vicksburg	7,473
101	Frio	Olig	S	Por	10,175	10,412	5	*x*	Frio	10,412
102	Frio	Olig	S	Por	8,182	9,370	10	DF	Frio	*y*
103	Cockfield, Yegua	Eoc	S	Por	6,952	6,954	2		Cockfield, Yegua	7,018
104	Mio, Frio	Mio, Olig	S	20*y*	2,407	5,712	29	DS	Vicksburg	7,891
105	Yegua	Eoc	S	27–31	7,547	7,676	10	DF	Yegua	8,110
106	Frio	Olig	S	Por	5,322	6,717			Oligocene	6,717
107	Cockfield	Eoc	S	Por	3,642	3,651	9	*x*	Yegua	3,907
108	L. Marginulina, Frio	Olig	S	30	5,157	6,140	200	DF	Vicksburg	8,793
109	Miocene	Mio	S	Por	5,150	6,300	10	DS	Oligocene	6,905
110	Mio, Frio	Mio, Olig	S	25	3,400	6,000	25	D	Frio	6,487
111	Cap rock, Miocene	Mio	S	Por	1,500	6,710	40	DS	Oligocene	7,179
112	Frio	Olig	S	Por	5,220	5,234	10	D	Frio	7,004
113	Miocene	Mio	S	Por	5,134	5,160	12	D	Frio	10,460
114	Cap rock, Frio	Cap rock, Olig	L S	Cav, Por	1,800	2,400	30	DS	Yegua	7,510

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942
115	Holzmark, *Bee*	1935	50	0	58,274	7,383	*y*	*y*
116	Hoards Creek, *Goliad*	1935	100	*y*	77,421	18,260	*y*	*y*
117	Hoskins Mound, *Brazoria*	1936	90		104,739	0	0	0
	Hull, *Liberty:*							
118	500-5000 ft	1918	850	0	96,165,406	2,237,982	*y*	*y*
119	4650-6600 ft	1932					*y*	*y*
	Humble, *Harris:*							
120	700-ft	1905	2,300	0	125,056,769	840,045	*y*	*y*
121	5670 ft	1928					*y*	*y*
122	Joe's Lake, *Tyler*	1937	2,350	*y*	1,219,838	736,214	*y*	*y*
123	Joyce Richardson, *Harris*	1940	150	*y*	76,658	33,906	*y*	*y*
124	Katy, *Waller*	1935		12,500	213,708	*y*	*y*	*y*
125	Keeran, *Victoria*	1932	640	640	1,752,542	118,831	*y*	*y*
126	Kubela, *Wharton*	1935	650	*y*	6,159,084	211,500	*y*	*y*
127	La Belle, *Jefferson*	1937	900	*y*	323,589	73,345	*y*	*y*
128	Lake Creek, *Montgomery*	1941	1,000	*y*	43,861	*y*	*y*	*y*
129	Lake View, *Wharton*	1941	20	40	*y*	*y*	*y*	*y*
130	Lamar, *Aransas*	1937	*y*	20*y*	1,095	0	0	0
131	La Rosa, *Refugio*	1938	1,720	0	3,585,969	359,752	*y*	*y*
132	League City, *Galveston*	1938	740	*y*	2,302,326	572,223	*y*	*y*
133	Lissie, *Wharton*	1940	500	*y*	839	0	*y*	*y*
134	Livingston, *Polk*	1933	1,800	*y*	7,266,182	567,850	*y*	*y*
135	Lochridge, *Brazoria*	1936	1,800	1,600	3,891,139	664,083	0	0
136	Lolita, *Jackson*	1940	3,100	*y*	3,919,235	2,258,006	*y*	*y*
137	Lost Lake, *Chambers*	1929	110	*y*	1,043,499	12,247	0	0
138	Louise, *Wharton*	1933	1,600	*y*	3,825,390	426,203	*y*	*y*
139	Lovells Lake, *Jefferson*	1938	2,650	*y*	4,287,206	1,797,114	*y*	*y*
140	Lucas, Mount, *Live Oak*	1923	120*y*	*y*	307,293	14,818	*y*	*y*
141	Lucky, *Matagorda*	1941	500	*y*	55,674	38,726	*y*	*y*
142	Magnet-Withers, *Wharton*	1936	14,000	*y*	14,025,781	4,195,632	*y*	*y*
143	Magnolia, *Montgomery*	1941	160	*y*	1,479	*y*	*y*	*y*
	Manvel, *Brazoria:*							
144	4016 ft	1931	1,800	*y*	23,255,463	1,910,144	*y*	*y*
145	5160 ft	1931					*y*	*y*
146	Markham, *Matagorda*	1908	250	*y*	8,953,438	321,831	*y*	*y*
147	Mathis, *Live Oak-San Patricio*	1924		120	*y*	*y*	*y*	*y*
148	Martha, *Liberty*	1939	500	*y*	454,639	187,532	*y*	*y*
149	Maurbro (Laward), *Jackson*	1941	3,275	*y*	708,330	505,367	*y*	*y*
150	Mauritz, *Jackson*	1935	200	*y*	568,420	65,699	*y*	*y*
151	Mayo, *Jackson*	1942	1,600	40	99,689*y*	99,689*y*	*y*	*y*
152	McFaddin, *Victoria*	1932	800	*y*	3,507,156	834,069	*y*	*y*
153	McMurray, *Bee*	1937	*y*	*y*	7,767	0	*y*	*y*
154	McNeil, *Live Oak*	1934	70	*y*	228,696	5,624	*y*	*y*
155	Medio Creek, *Bee*	1942		40	0	0	Shut in	
156	Melon Creek, *Refugio*	1939	210	*y*	560,998	150,747	*y*	*y*
157	Mercy, *San Jacinto*	1942	1,400	*y*	159,324	159,324	*y*	*y*
158	Millican (gas), *Brazos*	1942	0	40	0	0	*y*	*y*
159	Mineral, *Bee*	1937	*y*	*y*	*y*	*y*	*y*	*y*
160	Moss Bluff, *Liberty*	1930	10	0	210,265	0	*y*	0
161	Mission River, *Refugio*	1938	180*y*	*y*	968,395	250,608	*y*	*y*
162	Mountain View, *Live Oak*	1939	0	20	0	0	0	0
163	Mt. Houston (gas), *Harris*	1940		See Dyersdale				
164	Mustang Creek, *Jackson*	1942	40	0	*y*	*y*	*y*	*y*
	Mykawa, *Harris:*							
165	Shallow	1929	180	0	962,291	32,846	*y*	*y*
166	Deep	1930	150	0	3,666,559	158,109	*y*	*y*
167	Nash, *Fort Bend*	1926	260		1,725,359	500	*y*	*y*
168	Navidad, *Jackson*	1941	*y*	*y*	0	0	*y*	*y*

TABLE 1.—(*Continued*)

Line Number	Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil	
	Completed to End of 1942	During 1942		End of 1942			Number of Wells		Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
		Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift					
115	6	0	*y*	*y*	5	*y*	5	0	1,050	*y*	*y*	44.3	*y*
116	*y*	0	*y*	*y*	9	0	0	9	1,550	*x*	*y*	47.6	*y*
117	9	0	0	0	0	0	0	0	*x*	*x*	0	21.5	*x*
118	822	4	*y*	0	177	*y*	16	161	*x*	*x*	0	17–39	*y*
119									*x*	*x*	0	Above	*y*
120	1,815	5	*y*	*y*	238	*y*	17	221	*x*	*y*	0	17–45	*y*
121									*x*	*y*	0		*y*
122	46	0	*y*	*y*	42	0	41	1	1,425	*y*		40–47	*y*
123	7	0	*y*	*y*	2	*y*	2	0	*y*	*y*	1	42–58	*y*
124	20*y*	8	0	0	Gas-Dist.		*y*	0	*y*	*y*	0	*y*	*y*
125	34	0	*y*	*y*	23	*y*	17	6	1,450	*y*	0	36	*y*
126	21	0	*y*	*y*	19	*y*	9	10	*x*	*x*	0	*y*	*y*
127	8	0	*y*	*y*	4	*y*	4	0	7,000	*y*	0	37.2	0.06
128	13	10	0	*y*	9	1	*y*	*y*	*y*	*y*	0	61	*y*
129	3	1	0	0	1	2	3	0	*y*	*y*	0	24	*y*
130	1	0	0	0	0	1	1	0	*y*	*y*	0	Gas	*y*
131	96	0	*y*	*y*	84	8	82	2	850 1,775	*y* *y*	1	39	*y*
132	37	0	*y*	*y*	31	*y*	28	3	1,100 2,100	*x* *x*	0	40.5	*y*
133	1	0	0	0	0	0	0	0	*y*	*y*	0	58	*y*
134	99	1	*y*	*y*	76	*y*	5	71	700	*y*	*y*	40	*y*
135	47	0	0	1	42	*y*	32	10	2,100	*y*	0	26	*y*
136	177*y*	17	*y*	*y*	177	*y*	175	2	*y*	*y*	0	31.1–37	*y*
137	13	0	*y*	*y*	8	0	0	8	*x*	*x*	0	22.4	*y*
138	52*y*	1	*y*	*y*	36	*y*	5	31	1,850–1,300	*y*	0	26–38	*y*
139	94*y*	15	*y*	*y*	94	0	94	0	1,850	*y*	0	26	*y*
140	32	0	*y*	*y*	3	0	0	3	874 1,400	*y*	0	36	*y*
141	3	1	0	0	3	0	3	0	*y*	*y*	0	39	*y*
142	396*y*	70	*y*	*y*	396	*y*	376	20	2,350	*y*	0	25.4–26.1	*y*
143	1	0	0	0	0	0	0	0	*y*	*y*	0	57.7	*y*
144	195*y*	0	*y*	*y*	174	*y*	103	71	*x*	*y*	*y*	24	*y*
145									*x*	*y*	*y*	26	*y*
146	159*y*	1	*y*	*y*	40	*y*	11	29	*x*	*y*	0	25–40	*y*
147		4*y*	*y*	*y*	*y*	*y*	*y*	*y*	935	*y*	0	Gas	
148	12	0	*y*	*y*	12	*y*	11	1	3,509	*y*	0	41	*y*
149	57	35	*y*	*y*	57	*y*	55	2	*y*	*y*	0	24.4	*y*
150	8	0	*y*	*y*	8	*y*	7	1	2,467	*y*	0	31	0.11
151	21	21	1	0	20	1	21	0	*y*	*y*	0	27.8–34	*y*
152	93	7	*y*	*y*	89	*y*	76	13	1,185 1,725	*y*	0	21.2	*y*
153	*y*	0	0	0	0	0	0	0	570	*y*	*y*	47	*y*
154	7	0	*y*	*y*	4	0	4	0	1,150	*y*	0	44.3	*y*
155	1	1	0	0	0	Shut in	1	0	*y*	*y*	0	Gas	*y*
156	10	0	*y*	*y*	10	*y*	10	0	*x*	*y*	0	35.5	*y*
157	14	14	0	0	14	0	14	0	*y*	*y*	0	37–38	*y*
158	1	1	0	0	0	1	1	0	*y*	*y*	0	Gas	
159	12	0	*y*	*y*	*y*	*y*	*y*	*y*	100	*x*	*y*	45	*y*
160	5	0	0	0	0	0	0	0	280	*x*	0	*x*	*x*
161	18*y*	1	*y*	*y*	18	*y*	12	6	*y*	*y*	*y*	42.6	*y*
162	0	0	0	1	0	0	0	0	*x*	*x*	0	Gas	
163													
164	1	1	0	0	1	0	1	0	*y*	*y*	0	31.1	*y*
165	45	0	*y*	*y*	9	0	0	9	290	*y*	0	27.5	*y*
166		0	*y*	*y*	20	0	1	19	*y*	*y*	0	27.5	*y*
167	26	0	*y*	*y*	*y*	0	*y*	*y*	800	*x*	0	21.5–23	*y*
168	1	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	0	Gas	

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
					Depth, Avg. Ft.					
	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
115	Jackson	Eoc	S	Por	4,065	4,260	*y*	DF	Cockfield	4,458
116	Yegua	Eoc	S	Por	*y*	4,575	10	DF	Cook Mountain	6,004
117	Miocene	Mio	S	Por	600	4,126	23	DS	Miocene	4,126
118	Cap rock, Mio, Olig, Yegua, Cook Mt.	Mio, Olig, Eoc	S	Por	400	5,228	63	DS	Cook Mountain	9,669
119	Yegua	Eoc	S	Por	4,650	6,570	*y*	DS	Cook Mountain	9,669
120	Cap rock, Mio, Olig, Yegua	Mio, Olig, Eoc	S	Por	700	5,670	4	DS	Cook Mountain	8,181
121	Yegua	Eoc	S	Por			200			
122	Wilcox	Eoc	S	Por	7,600	7,736	30	DF	Wilcox	9,014
123	Cockfield	Eoc	S	Por	6,654	6,926	7	D	Cockfield	7,250
124	Yegua	Eoc	S	27–10.2	6,400	7,800	100	D	Wilcox	11,078
125	Frio	Olig	S	15	5,597	7,071	10	F	Vicksburg	10,043
126	Frio	Olig	S	Por	4,596	4,790	*y*	D	*y*	*y*
127	Marginulina	Olig	S	30	8,260	8,670	11	DS	Frio	10,147
128	Wilcox	Eoc	S	Por	9,200	9,800	50	DF	Wilcox	13,330
129	Miocene	Mio	S	Por	3,185	3,872	15	*y*	Cockfield	7,607
130	Frio	Olig	S	Por	7,502	7,997	*y*	*x*	Frio	9,785
131	Frio	Olig	S	30	5,322	6,385	20±	DF	Vicksburg	8,020
132	Frio	Olig	S	30	8,695	10,960	20	D	Vicksburg?	11,402
133	Yegua	Eoc	S	Por	6,728	6,734	6	*x*	Wilcox	10,116
134	Cockfield	Eoc	S	Por	3,285	4,360	20	DF	Wilcox	7,396
135	Frio	Olig	S	20	6,309	6,387	20	DF	Vicksburg	9,684
136	Frio	Olig	S	32	5,274	6,398	10*y*	D	Frio	7,280
137	Frio	Olig	S	Por	2,679	5,157	33	DS	Frio	7,471
138	Marginulina, Frio	Olig	S	Por	5,135	7,143	15	DF	Vicksburg	8,271
139	Frio	Olig	S	30	7,713	7,792	22	DF	Frio	8,189
140	Mio, Frio, Yegua	Mio, Olig, Eoc	S	Por	1,750	5,300	28	D	Cook Mountain	6,789
141	Frio	Olig	S	Por	8,883	8,886	10	DF	Frio	10,500
142	Marg, Frio	Olig	S	Por	5,490	5,560	20	AF	Vicksburg	9,200
143	Wilcox	Eoc	S	Por	8,448	8,458	10	DF	Wilcox	10,008
144	Miocene	Mio	S	27.9	3,990	4,016	23	DF	Vicksburg	7,957
145	Frio	Olig	S	22.5	5,000	5,500	26			
146	Cap rock, Mio	Cap Mio	L S	Cav Por	936	4,350	20	DS	Vicksburg	6,436
147	Miocene	Mio	S	Por	2,375	2,385	10	ML	Jackson	5,526
148	Yegua	Eoc	S	30	8,100	8,108	5	DF	Yegua	9,109
149	Marginulina, Frio	Olig	S	Por	5,220	5,230	10	DF	Frio	6,520
150	Frio	Olig	S	Por	5,640	5,650	8	DF	Frio	7,408
151	Frio	Olig	S	Por	5,324	7,808	6–20	DF	Vicksburg	7,808
152	Mio Heterostegina, Frio	Mio, Olig	S	Por	2.440 4,400	2,470 5,300	24 10	AF	Frio	7,025
153	Yegua	Eoc	S	Por	4,267	4,284	8	DF	Yegua	4,379
154	Jackson, Cockfield	Eoc	S	Por	4,434	4,992	10	D	Cook Mountain	6,212
155	Frio, Vicksburg	Olig	S	Por	4,855	5,320	10	*y*	Jackson	6,160
156	Frio	Olig	S	Por	5,856	5,876	20	D	Frio	5,876
157	Wilcox	Eoc	SH	17±	8,250	8,925	20	DF	Wilcox	8,925
158	Wilcox	Eoc	S	Por	3,342	3,498	6	DS	Wilcox	5,511
159	Cockfield	Eoc	S	Por	3,545	3,560	8	DF	Cockfield	4,536
160	Cap rock, Marginulina	Cap, Olig	L S	Cav Por	800	5,800	33	DS	Vicksburg	7,375
161	Frio	Olig	S	Por	5,445	7,150	15	D	Vicksburg	9,225
162	Jackson	Eoc	S	Por	2,476	2,481	5	F	Cockfield	3,010
163										
164	Frio	Olig	S	Por	6,644	6,651	7	*x*	Frio	6,762
165	Miocene	Mio	S	Por	4,100	4,300	30	DF	Yegua	7,178
166	Frio	Olig	S	Por	4,400	4,892	30			
167	Mio, Frio	Mio, Olig	S	Por	3,700	5,677	60*y*	DS	Vicksburg	7,965
168	Miocene	Mio	S	Por	3,788	3,796	8	DF	Vicksburg	7,553

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942
169	Needville, *Fort Bend*	1941	60	40	39,587	39,587	*y*	*y*
170	Nome, *Jefferson*	1936	750	*y*	2,847,424	474,126	*y*	*y*
171	Nordheim, *Dewitt*	1942	40	*y*	*y*	*y*	*y*	*y*
172	Normanna, *Bee*	1930	70	10	62,695	3,532	*y*	*y*
173	North Bay City, *Matagorda*	1942	100	0	5,171	5,171	*y*	*y*
	North Dayton, *Liberty:*							
174	1200 ft	1905	50	0	2,252,767	4,318	*y*	*y*
175	4800 ft	1927			Included above		*y*	*y*
176	North Houston, *Harris*	1938	1,000	*y*	192,167	46,534	*y*	*y*
177	North Keeran, *Victoria*	1940	20	0	*y*	*y*	*y*	*y*
178	North Laward, *Jackson*	1941	4,000	*y*	573,748	543,334	*y*	*y*
179	North Markham, *Matagorda*	1938	1,350	*y*	459,534	184,860	*y*	*y*
180	North McFaddin, *Victoria*	1937	300	500	63,565	13,135	*y*	*y*
181	North Normanna, *Bee*	1938	10	0	776	0	0	0
182	North Withers, *Wharton*	1942	Included with Magnet-Withers					
183	Oakville, *Live Oak*	1936	250	*y*	840,866	257,931	*y*	*y*
184	O'Connor, *Refugio*	1931	140	*y*	597,239	19,136	*y*	*y*
185	Old Ocean, *Brazoria*	1934	10,300	*y*	18,393,876	3,728,036	*y*	*y*
186	Orange, *Orange*	1913	400	*y*	33,445,520	142,506	*y*	*y*
187	Orange Hill, *Austin*	1942	40	*y*	*y*	*y*	*y*	*y*
188	Orchard, *Fort Bend*	1926	150	50	3,665,436	41,229	*y*	*y*
189	Oyster Bayou, *Chambers*	1941	1,400		173,475	131,434	*y*	*y*
190	Palacios, *Matagorda*	1937	300	*y*	117,149	3,852	0	0
191	Pettus, *Bee*	1930	1,200	1,220	12,346,338	47,293*y*	*y*	*y*
192	Pettus, New, *Bee, Goliad, Karnes*	1930	950	50	777,947	95,422	*y*	*y*
193	Picketts Ridge, *Wharton*	1935	1,200	*y*	3,520,600	452,734	*y*	*y*
194	Pierce Junction, *Harris*	1921	340	0	36,049,013	570,094	*y*	*y*
195	Placedo, *Victoria*	1935	1,980	*y*	13,607,600	1,132,957	*y*	*y*
196	Pledger, *Brazoria*	1932	*y*	*y*	17,000	Gas	*y*	*y*
197	Plummer, *Bee*	1936	160	220	284,738	13,972	*y*	*y*
198	Port Lavaca, *Calhoun*	1934	220	*y*	363,071	*y*	*y*	0
199	Port Neches, *Orange*	1928	640	*y*	5,536,018	108,911	*y*	0
200	Port Neches, West, *Orange*	1936		*y*	762,078	252,402	*y*	0
201	Powderhorn Lake, *Calhoun*	1939	0	40	0	0	*y*	*y*
	Raccoon Bend, *Austin:*							
202	3490 ft	1927	1,624	*y*	18,658,876	438,960	*y*	*y*
203	4120 ft	1934	1,470	600	7,004,397	1,148,550	*y*	*y*
204	Ramers Island, *Tyler*	1942	40	*y*	*y*	*y*	*y*	*y*
205	Ray, *Bee*	1934	420	0	1,604,299	26,209	*y*	*y*
206	Red Fish Reef, *Chambers*	1940	1,020	*y*	434,960	251,407	*y*	*y*
207	Refugio, *Refugio*	1922	4,845	6,450	40,325,170	1,219,199	*y*	*y*
208	Refugio-Fox, *Refugio*	1940	150	*y*	4,236,982	78,580	*y*	*y*
209	Rockland, *Jasper*	1929	20	*y*	43,315	2,693	*y*	*y*
210	Rooke, *Refugio*	1942	*y*	*y*	*y*	*y*	0	0
211	Rosslyn, *Harris*	1938	100	*y*	39,917	2,896	*y*	*y*
212	Rosenberg, *Fort Bend*	1939	200	*y*	19,234	Shut in	*y*	*y*
213	Rowan, *Brazoria*	1940	460	*y*	290,837	104,370	*y*	*y*
214	Sabine Pass, *Jefferson*	1941	50	0	11,505	622	*y*	*y*
215	Sandy Point, *Brazoria*	1937	80	0	313,069	35,006	*y*	*y*
216	Saratoga, *Hardin*	1901	500	*y*	29,960,146	272,438	*y*	*y*
217	Sarco, *Goliad*	1938	40	*y*	3,330	347	*y*	*y*
218	Satsuma, *Harris*	1936	540	*y*	655,141	85,073	*y*	*y*
219	Schwab (Ace), *Polk*	1934	200	10	479,824	62,973	*y*	*y*
220	Schwab-Wilcox, *Polk*	1939	200	0	Included above		0	0
221	Seabreeze, *Chambers*	1936	650	*y*	503,165	110,033	*y*	*y*
222	Sealy, *Austin*	1942	40	0	*y*	*y*	*y*	*y*
	Segno, *Polk:*							
223	Shallow	1936	425	*y*	2,564,796	276,697	*y*	*y*
224	Deep	1938	2,100	*y*	3,957,050	1,003,726	*y*	*y*
225	Shepard, *San Jacinto*	1940	40*y*	*y*	14,804	0	*y*	*y*
226	Shepards Mott, *Matagorda*	1936	*y*	0	2,425	0	0	0

TABLE 1.—(*Continued*)

Line Number	Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation^d	Character of Oil	
	Completed to End of 1942	During 1942		End of 1942			Number of Wells		Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
		Completed	Abandoned	Temporarily Shut Down	Producing Oil^c	Producing Gas^c	Flowing	Artificial Lift					
169	5	*y*	0	0	3	*y*	3	0	*y*	*y*	0	24.1	*y*
170	44	0	*y*	*y*	32	*y*	19	13	2,550	*y*	0	26.9	0.25
171	1	1	0	0	1	0	1	0	*y*	*y*	0	40	*y*
172	7	0	*y*	*y*	3	0	1	2	150	*y*	*y*	38.8	*y*
173	4	4	0	0	4	0	4	0	*y*	*y*	0	34.4–35.4	*y*
174	64	0	*y*	*y*	3	0	0	3	*x*	*x*	0	22–33	*y*
175	Included above								400	*x*	0	Included above	
176	6	1	*y*	*y*	4	1	5	0	*y*	*y*	*y*	*y*	*y*
177	2	0	0	0	1	Shut in	1	0	*y*	*y*	0	*y*	*y*
178	69	60	0	0	69	*y*	67	2	*y*	*y*	0	25.8	*y*
179	22	3	0	0	22	*y*	22	0	3,450	*y*	0	36	*y*
180	23	1	0	0	6	17	3	0	*y*	*y*	0	37–41.8	*y*
181	1	0	0	0	0	0	0	0	*y*	*y*	0	46.5	*y*
182	Included with Magnet-Withers												
183	45*y*	9	*y*	*y*	31	*y*	24	7	1,300	*y*	0	23	*y*
184	10	0	*y*	*y*	4	0	0	4	365	*y*	0	22.6	*y*
185	109*y*	8	0	0	109	*y*	108	1	4,700	*y*	0	52–68	*y*
186	328	0	*y*	*y*	37	*y*	0	37	*x*	*y*	0	20–42	*y*
187	1	1	0	0	1	0	1	0	*y*	*y*	0	44.8	*y*
188	35	0	*y*	*y*	9	*y*	3	6	375	*y*	0	22–51.5	*y*
189	12	6	0	0	12	0	12	0	*y*	*y*	0	35.9	*y*
190	5	0	*y*	*y*	2	*y*	2	0	*x*	*y*	0	54	*y*
191	90*y*	1	*y*	*y*	28	*y*	0	28	236	*y*	*y*	45	*y*
192	50*y*	0	*y*	*y*	50	0	0	50	*y*	*y*	*y*	47.5	*y*
193	51	0	0	*y*	46	*y*	27	19	2,053	*y*	0	25–26	*y*
194	200	4	*y*	*y*	65	*y*	11	54	355	*y*	0	21–41	*y*
195	182	3	*y*	*y*	159	*y*	55	104	1,900	*y*	0	25	*y*
196	13	1	*y*	*y*	0	*y*	*y*	0	2,450	*y*	0	55.8	*y*
197	15*y*	0	*y*	*y*	11	*y*	6	5	1,010	*y*	0	25	*y*
198	13	0	*y*	*y*	*y*	*y*	*y*	*y*	*x*	*y*	0	61	*x*
199	48	0	*y*	*y*	15	*y*	3	12	*y*	*y*	0	25	*y*
200		2	*y*	*y*	28	0	23	5	1,850	*y*	0	38	*y*
201	1	0	0	0	0	1	1	0	*y*	*y*	0	54	*y*
202	250	0	0	*y*	76	*y*	1	75	275	*y*	0	26	*y*
203		0		*y*	84	*y*	65	19	1,800	*y*	0	33.5	*y*
204	1	1	0	0	1	0	1	0	*y*	*y*	0	45	*y*
205	42*y*	0	*y*	*y*	10	*y*	0	10	1,755	*y*	0	46	*y*
206	20	3	0	0	15	*y*	15	0	*y*	*y*	0	35.6–57	*y*
207	500*y*	5	*y*	*y*	145	*y*	99	46	*y*	*y*	*y*	33–39	*y*
208	18		*y*	*y*	18	*y*	15	3	*y*	*y*	0	38–42	*y*
209	10	0	*y*	*y*	*y*	0	*y*	*y*	*x*	*y*	0	21–35	*y*
210	3	3	0	0	3	0	3	0	*y*	*y*	0	37.5–40.9	*y*
211	1	0	0	0	1	0	1	0	1,800	*y*	0	39.2	*y*
212	2	0	*y*	*y*	Shut in		0	0	*y*	*y*	0	55	*y*
213	7	0	0	0	7	0	7	0	*y*	*y*	0	40–53	*y*
214	2	0	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	0	26.7	*y*
215	11	0	*y*	*y*	3	0	0	3	2,680	*y*	0	46.2	*y*
216	778	2	*y*	*y*	221	0	0	221	*y*	*y*	0	17–21	*y*
217	1	0	*y*	*y*	*y*	*y*	*y*	*y*	*x*	*x*	0	35	*y*
218	17	1	*y*	*y*	8	*y*	3	5	3,100	*y*	0	42–45	*y*
219	5	0	0	*y*	*y*	*y*	*y*	1	*y*	*y*	0	40.5–53	*y*
220	5	0	0	0	5	0	5	0	*y*	*y*	0	34.2–36.4	0.10
221	15	2	*y*	*y*	11	*y*	11	0	3,900	*y*	0	40	*y*
222	1	1	0	0	1	0	1	0	*y*	*y*	0	48.9	*y*
223	37	0	*y*	*y*	37	*y*	28	9	1,450	*y*	0	36–44	*y*
224	81	1	0	0	81	*y*	77	4	950	*y*	0	36.8	*y*
225	1	0	0	0	0	0	0	0	*y*	*y*	0	55.7	*y*
226	1	0	0	*y*	*y*	*y*	0	0	*y*	*y*	0	*y*	*y*

TABLE 1.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
169	Frio	Olig	S	Por	5,176	5,194	8	DF	Yegua	11,132
170	Marginulina	Olig	S	Por	4,775	6,060	12	DF	Vicksburg	9,045
171	Wilcox	Eoc	S	Por	7,027	8,500	10	*x*	Wilcox	8,500
172	Jackson	Eoc	Sh	Por	3,500	3,676	17	D	Yegua	5,038
173	Frio	Olig	S	Por	7,864	8,851	*y*	DF	Frio	8,851
174	Cap rock, Mio	Cap Mio	L S	Cav Por	400	5,188	*x*	DS	Oligocene	5,700
175	Oligocene	Olig	S	Por						
176	Yegua	Eoc	S	Por	*y*	*y*	*y*	DF	*y*	*y*
177	Frio	Olig	S	Por	5,550	5,552	2	DF	Vicksburg	7,509
178	Frio	Olig	S	Por	5,207	5,628	10	DF	Vicksburg	7,735
179	Frio	Olig	S	Por	7,702	7,770	20	DF	Frio	8,503
180	Frio	Olig	S	Por	3,500	6,214	10 ±		Oligocene	7,506
181	Cockfield	Eoc	S	Por	4,218	4,258	5	*x*	Cockfield	4,273
182	Included with Magnet-Withers									
183	Mio, Olig, Jackson, Cockfield	Mio, Olig Eoc	S	Por	265	2,816	8	AF	Cook Mountain	4,500
184	Miocene	Mio	S	Por	2,136	4,150	8	AF	Frio	6,860
185	Frio	Olig	S	27	8,636	10,670	200	D	Frio	11,357
186	Mio, Frio	Mio, Olig	S	Por	2,500	6,123	30*y*	DS	Frio	7,604
187	Wilcox	Eoc	S	Por	9,052	10,104	*x*		Wilcox	10,104
188	Cap rock, Mio, Frio, Yegua	Cap Mio, Olig Eoc	L S S	Cav 20	1,265	7,975	25	DS	Cook Mountain	10,085
189	Frio	Olig	S	Por	8,250	8,280	0*y*	DF	Frio	8,835
190	Frio	Olig	S	Por	7,830	9,275	15	D	Frio	11,327
191	Cockfield	Eoc	S	Por	3,860	3,900	19	DF	Wilcox	8,993
192	Cockfield	Eoc	S	Por	3,616	3,926	15	DF	Cook Mountain	7,569
193	Frio	Olig	S	33	4,596	4,790	10–25	A	Jackson	8,888
194	Mio, Frio, Vicksburg	Mio, Olig	S	Por	3,142	6,943	45*x*	DS	Jackson	7,165
195	Heterostegina, Frio	Olig	S	Por	4,745	6,370	20	AF	Frio	7,242
196	Marginulina, Frio	Olig	S	Por	6,580	6,684	100	D	Vicksburg	8,061
197	Cockfield	Eoc	S	Por	3,036	4,277	*y*	DF	Cook Mountain	4,756
198	Marginulina	Olig	S	Por	6,240	6,250	10	DF	Oligocene	9,255
199	Mio, Frio	Mio, Olig	S	Por	3,150	5,942	40	DS	Vicksburg	7,667
200										
201	Miocene	Mio	S	Por	4,628	4,635	7	DF	Miocene-Oligocene	6,652
202	Jackson	Eoc	S	Por	3,149	3,400	18	DF	Wilcox	8,589
203	Cockfield	Eoc	S	Por	3,960	4,150	40	DF	Wilcox	8,589
204	Yegua	Eoc	S	Por	5,397	5,400	3	*x*	Wilcox	8,454
205	Cockfield	Eoc	S	Por	3,888	3,944	15	DF	Yegua	4,253
206	Frio	Olig	S	Por	8,796	10,995	15	DF	Frio	11,008
207	Mio, Frio	Mio, Olig	S	Por 30	3,687 4,900	*y* 6,600	30	DF	Vicksburg	9,225
208	Marginulina	Olig	S	34	3,545	5,900	10	D	Frio	7,300
209	Jackson, Yegua	Eoc	S	Por	1,275	*x*	6	Mf	*y*	3,000
210	Frio	Olig	S	Por	7,122	8,551	*y*	DF	Frio	8,551
211	Yegua	Eoc	S	Por	6,947	6,956	9	*x*	Yegua	7,495
212	Cockfield	Eoc	S	Por	7,713	7,743	10	DF	Cook Mountain	8,530
213	Frio	Olig	S	Por	8,538	8,554	18	*y*	Frio	10,010
214	Miocene	Mio	S	Por	4,053	4,992	7	*y*	Miocene	7,097
215	Marginulina	Olig	S	30	6,480	6,500	3	DF	Vicksburg	8,943
216	Cap rock, Mio, Olig	Cap Mio, Olig	L S	Cav Por	500	3,220	17	DS	Cook Mountain	7,461
217	Frio, Vicksburg	Olig	S	Por	5,013	5,023	*x*	F	Yegua	6,702
218	Yegua	Eoc	S	Por	6,803	8,050	15	DF	Cook Mountain	8,050
219	Cockfield	Eoc	S	Por	4,805	4,862	10	DF	Wilcox	8,553
220	Wilcox	Eoc	S	Por	7,748	8,553	20	DF	Wilcox	8,553
221	Frio	Olig	S	Por	8,105	8,795	40	DF	Frio	9,637
222	Wilcox	Eoc	S	Por	8,724	11,505	51	*x*	Wilcox	11,505
223	Cockfield	Eoc	S	Por	5,150	5,200	10	DF	Wilcox	11,734
224	Wilcox	Eoc	S	17.5	8,190	9,150	30	DF	Wilcox	11,734
225	Wilcox	Eoc	S	Por	8,215	8,277	*y*	*y*	Wilcox	8,590
226	Frio	Olig	S	Por	8,646	8,853	*y*	D	Frio	9,210

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942
227	Sheridan, *Colorado*	1940	1,550*y*	*y*	121,456	41,997	*y*	*y*
228	Silsbee, *Hardin*	1936	1,000	*y*	3,333,425	690,809	*y*	*y*
229	Slick, *Goliad-Dewitt*	1930	80	240	79,993	62	*y*	*y*
230	Smith Point, *Chambers*	1940			See Red Fish Reef			
231	Sour Lake, *Hardin*	1902	900	*y*	80,239,212	320,696	*y*	*y*
232	South Caesar, *Bee*	1942	600*y*	*y*	86,064*y*	86,064*y*	*y*	*y*
233	South China, *Jefferson*	1939	250	*y*	417,578	115,573	*y*	*y*
234	South Houston, *Harris*	1935	620	*y*	7,430,068	668,225	*y*	*y*
235	South Liberty, *Liberty*	1925	250	*y*	15,992,814	117,153	*y*	*y*
236	South White Creek, *Live Oak*	1941	*y*	*y*	61,630	56,510	*y*	*y*
237	Spanish Camp, *Wharton*	1936	0	2,000	*y*	Gas	*y*	*y*
238	Spindletop, *Jefferson*	1901	400	*y*	128,405,556	419,082	*y*	*y*
239	Deep	1925			Included above			
240	Splendora, *Montgomery*	1934	100	*y*	1,000	0	*y*	*y*
241	Steamboat Pass, *Calhoun*	1941	0	40	0	0	*y*	*y*
242	Stewart, *Jackson*	1942	350	40	26,768	26,768	*y*	*y*
243	Stowell, *Jefferson*	1941	800		263,621	260,954	*y*	*y*
244	Stratton Ridge, *Brazoria*	1932	25	0	33,845	0	0	0
245	St. Charles, *Aransas*	1940	60	0	24,961	8,232	0	0
246	Sugarland, *Fort Bend*	1928	1,200	*y*	31,328,932	617,384	*y*	*y*
247	Telferner, *Victoria*	1937	30	30	50,417	5,625	*y*	*y*
248	Terrell, *Victoria*	1940	40	0	13,415	3,085	0	0
249	Texana, *Jackson*	1939	100*y*	0	23,264	8,683	*y*	*y*
250	Thomaston, *Dewitt*	1940	40	*y*	8,248	1,044	*y*	*y*
251	Thompsons, *Fort Bend*	1931	6,515		48,798,322	5,390,089	*y*	*y*
252	Vicksburg	1939					*y*	*y*
253	Tomball, *Harris*	1933	8,900	*y*	22,863,553	3,114,943	*y*	*y*
254	Tom O'Connor, *Refugio*	1934	8,920	0	33,570,343	6,914,652	*y*	*y*
255	Tuleta, West, *Bee*	1932	1,160	0	1,866,252	22,992	*y*	*y*
256	Tulsita, *Bee*	1938	120	*y*	11,193	1,479	*y*	*y*
257	Turtle Bay, *Chambers*	1935	875	*y*	2,486,522	494,381	*y*	*y*
258	Tynan, *Bee*	1942	40	0	*y*	*y*	0	0
259	Vanderbilt, *Jackson*	1934			Included with West Ranch			
260	Victoria, *Victoria*	1939	240	50*y*	316,613	97,659	*y*	*y*
261	Vienna, *Lavaca*	1941	40	*y*	1,496	*y*	*y*	*y*
262	Voss, *Bee*	1936	95	0	77,340*y*	*y*	0	0
263	Webster (Friendswood), *Harris*	1937	4,000	*y*	12,619,189	3,619,963	*y*	*y*
264	Weser, *Goliad*	1936	140	*y*	31,896	6,413	*y*	*y*
265	West Aldine, *Harris*	1942	40		1,136		*y*	*y*
266	West Beaumont, *Jefferson*	1936	650	*y*	4,584,981	726,600	*y*	*y*
267	West Columbia, *Brazoria*	1914	700	*y*	82,977,012	754,718	*y*	*y*
268	New	1936			6,527,811	1,235,275	*y*	*y*
269	West Ganado, *Jackson*	1940	1,500	*y*	421,011	326,661	*y*	*y*
270	West Garwood, *Colorado*	1941	200*y*	0	84,662	40,220	*y*	*y*
271	West Mauritz, *Jackson*	1942	500	0	34,523	34,523	*y*	*y*
272	West Orange, *Orange*	1937	250	0	2,662,223	544,446	*y*	*y*
273	West Ranch, *Jackson*	1938	10,000	*y*	11,263,348	5,243,272	*y*	*y*
274	West Tuleta, *Bee*		*y*	*y*	*y*	*y*	*y*	*y*
275	West Sisbee, *Hardin*	1941	250	*y*	47,769	24,089	*y*	*y*
276	White Creek, *Live Oak*	1939	300*y*	10	335,586	89,388	*y*	*y*
277	Willow Slough, *Chambers*	1937	850	*y*	447,727	66,790	*y*	*y*
278	Withers, *Wharton*	1936			Included with Magnet-Withers			
279	Wilson Creek, *Matagorda*	1937	80	0	91,419	8,867	*y*	*y*
280	Woodsboro, *Refugio*	1941	80*y*	*y*	56,478	24,588	*y*	*y*
281	Worth, *Bee*	1935	50	0	*y*	*y*	*y*	*y*
282	Yorktown, *Dewitt*	1942	40	0	*y*	*y*	0	0

TABLE 1.—(*Continued*)

Line Number	Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operations[d]	Character of Oil	
	Completed to End of 1942	During 1942		End of 1942			Number of Wells		Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
		Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift					
227	7	3	0	0	7	y	7	0	y	y	0	34–56.8	y
228	51	0	y	y	42	y	29	13	574	y	0	36–43	y
229	5y	0	y	y	y	y	y	y	550	y	0	46	y
230									See Red Fish Reef				
231	809	3	y	y	156	0	10	146	x	x	0	16–31	y
232	13	13	0	0	13	0	13	0	y	y	0	38.2–42.2	y
233	16	0	y	y	15	y	14	1	y	y	0	37–52	y
234	91	0	y	y	90	y	68	22	2,085	y	0	19.5–25.5	y
235	317	0	y	y	38	0	4	34	50	y	0	21–47	y
236	5	1	y	y	5	y	5	0	y	y	0	y	y
237	12	1	0	y	0	12	12	0	1,300	y	0	Gas	y
238	1,385	0	y	y	114	y	7	134	x	x	0	25	y
239					Included above					Included above			
240	1	0	0	0	0	0	0	0	2,000		0	69	y
241	1	0	0	0	0	1	1	0	y	y		Gas	y
242	6	6	0	1	6	0	6	0	y	y	0	24–26.7	y
243	12	12	0	0	11	y	11	0	y	y	0	34.5	y
244	5	0	0	0	0	0	0	0	x	x	0	32.5	x
245	2	1	0	0	2	0	2	0	y	y	0	32.5	y
246	71	0	y	y	52	0	34	18	1,570	y	0	28–35	y
247	4	0	0	y	2	y	0	2	900	y	0	27.8	y
248	1	0	y	y	1	y	0	1	800	y	0	y	y
249	3	2	y	y	1	2	1	0	x	y	0	52	y
250	2	0	0	y	y	y	y	y	x	y	0	30.6–52.3	y
251	374	0	y	y	82	0	80	2	y	y	0	25–43	y
252		1	0	y	38	0	38	0	y	y	0		y
253	537	1	y	y	456	y	318	138	2,490	y	y	37–41	y
254	451	0	y	y	448	y	447	1	1,040	y	0	35.5	y
255	75	0	y	y	17	y	3	14	792	y	y	44.5–50	y
256	12	0	0	y	1	0	0	1	y	y	y	45	y
257	39	0	y	y	37	y	30	7	2,958	y	0	32	x
258	1	1	0	0	1	0	1	0	y	y	0	23	y
259									Included with West Ranch				
260	26	1	y	y	16	y	3	13	y	y	0	22.5	y
261	1	0	y	y	0	0	0	0	y	y	0	50	y
262	8	0	0	0	0	0	0	0	y	y	0	45	y
263	212	0	y	y	211	y	209	2	950	y	0	20–30	y
264	10	0	y	y	3	y	1	2	750	y	0	46.5	y
265	1	1	0	0	1		1	0	y	y	0	39.6	y
266	59	5	0	y	59	y	25	34	y	y	0	26–34	y
267	379	4	y	y	45	0	18	27	y	y	0	28	y
268		0	y	y	103	0	94	9	2,452	y	0	28	y
269	32	9	y	y	32	y	32	0	y	y	0	24.5	y
270	5	0	y	y	3	y	3	0	y	y	0	52.4	y
271	7	7	0	0	7	0	7	0	y	y	0	28–33.8	
272	48	0	0	y	42	y	19	23	y	y	0	24.5	y
273	377y	23	y	y	377	2y	373y	4	1,700	y	0	30.3	y
274	3	1	2	0	3	0	3	0	y	y	0	47.6	y
275	2	0	y	y	2	y	2	0	y	y	0	40.8	y
276	35	0	0	y	30	y	y	y	x	y	y	21	y
277	7	0	0	0	7	0	7	0	3,900	y	0	34–37	0.07
278							Included with Magnet Withers						
279	2	0	0	0	1	0	1	0	y	y	0	51–51.5	y
280	4	0	y	y	3	0	3	0	y	y	0	40–60	y
281	2y	y	y	y	y	y	y	y	850	y	0	30.3	y
282	1	1	0	0	1	0	1	0	y	y	0	62.8	y

TABLE I.—(*Continued*)

Line Number	Producing Formation								Deepest Zone Tested to End of 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottoms Prod. Wells				
227	Wilcox	Eoc	S	Por	8,133	10,830	30	D	Wilcox	11,497
228	Cockfield	Eoc	S	Por	6,845	6,965	20	DF	Cook Mountain	7,778
229	Yegua	Eoc	S	Por	4,199	4,404	10	DF	Yegua	4,580
230										
231	Mio, Olig, Yegua	Mio, Olig, Eoc	S	Por	500	6,804	100	DS	Yegua	7,914
232	Wilcox	Eoc	S	Por	6,548	6,673	y	DF	Wilcox	7,507
233	Frio	Olig	S	Por	7,491	7,885	30	DF	Frio	8,785
234	Mio, Frio	Mio, Olig	S	30	3,845	4,775	75	DS	Cockfield	9,474
235	Mio, Olig, Yegua	Mio, Olig, Eoc	S	Por	700	4,996	100	DS	Yegua	4,996
236	Cockfield	Eoc	S	Por	1,844	1,852	8	DF	Yegua	2,448
237	Miocene	Mio	S	Por	2,910	3,020	30	D	Yegua	8,183
238	Cap rock	Cap	L	Cav	800	1,200	x }	DS	Frio	7,382
239	Mio, Frio	Mio, Olig	S	Por	2,920	5,900	69 }			
240	Cockfield	Eoc	S	Por	5,828	5,840	12	D	Yegua	6,452
241	Miocene	Mio	S	Por	2,880	2,885	5	DF	Oligocene	6,406
242	Marginulina, Frio	Olig	S	Por	4,984	5,948	10	DF	Oligocene	7,508
243	Frio	Olig	S	Por	8,850	8,880	12y	DF	Frio	10,236
244	Miocene	Mio	S	Por	4,300	4,500	10	DS	Oligocene	9,267
245	Frio	Olig	S	Por	7,604	7,618	14	D	Frio	9,335
246	Marginulina, Frio	Olig	S	25	2,900	3,800	80	DS	Yegua	7,521
247	Mio, Frio	Mio, Olig	S	Por	2,525	3,600	y	DF	Cook Mountain	7,666
248	Frio	Olig	S	Por	5,274	5,284	10	x	Oligocene	5,403
249	Frio	Olig	S	Por	5,686	5,770	10	D	Vicksburg	8,724
250	Wilcox	Eoc	S	14–43	7,855	7,922	18	x	Wilcox	8,518
251	Mio, Frio	Mio, Olig	S	25	3,050	5,409	80	DF	} Vicksburg	9,001
252	Vicksburg	Olig	S	25	7,700	7,800	100	DF		
253	Cockfield, Yegua	Eoc	S	25	y	5,682	10	DF	Wilcox	8,955
254	Frio	Olig	S	Por	5,176	5,948	100	ALF	Frio	8,174
255	Jackson, Cockfield, Wilcox	Eoc	Sh	Por	3,065	7,535	11+	DF	Wilcox	7,921
256	Cockfield	Eoc	S	Por	3,504	3,590	26	DF	Cockfield	3,598
257	Marginulina, Frio	Olig	S	Por	6,550	8,497	8	DF	Vicksburg	8,497
258	Frio, Vicksburg	Olig	S	Por	4,212	4,750	1	x	Frio-Vicksburg	4,750
259										
260	Mio, Frio, Vicksburg	Mio, Olig	S	Por	{ 2,551 3,035 4,776	2,635 3,094 4,781 }	10	DLF	Vicksburg	5,252
261	Wilcox	Eoc	S	Por	8,468	8,476	10	x	Wilcox	8,524
262	Cockfield	Eoc	S	Por	3,985	4,017	5y	DF	Yegua	4,306
263	Frio	Clig	S	30	5,488	6,050	150	DF	Vicksburg	8,452
264	Yegua, Cook Mt.	Eoc	S	Por	4,802	5,310	10	F	Cook Mountain	5,313
265	Yegua	Eoc	S	Por	7,190	7,991	3	x	Yegua	7,991
266	Mio, Olig	Mio, Olig	S	Por	4,560	6,756	10–20	DF	Vicksburg	8,501
267	Mio, Frio	Mio, Olig	S	Por	354	y	250± }	DS	Vicksburg	8,518
268	Frio	Olig	S	Por	5,200	5,784	100 }			
269	Frio	Olig	S	Por	5,204	5,220	16	DF	Oligocene	6,623
270	Yegua, Wilcox	Eoc	S	Por	{ 6,104 9,425	6,157 10,012	6 15 }	DF	Wilcox	10,012
271	Frio	Olig	S	Por	5,451	6,760	y	DF	Frio	6,760
272	Frio	Olig	S	Por	5,585	6,123	8	DS	Frio	7,550
273	Frio	Olig	S	28.4	5,086	5,780	40	DF	Vicksburg	8,527
274	Wilcox	Eoc	S	Por	7,525	7,590	30	DF	Wilcox	9,200
275	Cockfield	Eoc	S	Por	6,918	6,923	5	DF	Cook Mountain	7,778
276	Jackson	Eoc	S	Por	1,300	1,550	7	DLF	Jackson	1,785
277	Frio	Eoc	S	25	8,400	8,860	10	D	Frio	9,044
278	with Magnet Withers									
279	Frio	Olig	S	Por	9,968	10,796	28	x	Frio	10,796
280	Frio	Olig	S	Por	5,833	6,500	5	DF	Frio	6,710
281	Cockfield	Eoc	S	Por	3,407	y	5	D	Cockfield	3,708
282	Wilcox	Eoc	S	Por	7,192	9,150	12		Wilcox	9,150

20/64-in. choke. Two other wells were drilled during 1942, both of which were abandoned as failures. The Alief discovery is the result of geophysical work. Because of its trend position it appears unimportant.

Berclair, Bee County.—The Magnolia Petroleum Co. drilled No. 1 Buckner to 10,561 ft. in Wilcox. Three production tests were made through perforations: (1) 10,370 to 10,404 ft. flowed 20 bbl. of 56.5° gravity oil and 300,000 cu. ft. of gas through ¼-in. choke, tubing pressure 950 lb., casing pressure 1150 lb.; (2) 10,020 to 10,150 ft. flowed 14 bbl. of 54.5° gravity oil through 9/64-in. choke, tubing pressure 750 lb., casing pressure 1350 lb., gas-oil ratio 23,000 to 1; (3) same perforations as test No. 2 flowed 8½ bbl. through 3/16-in. choke, tubing pressure 725 lb., casing pressure 1175 lb., gas-oil ratio 38,000 to 1. The well was temporarily abandoned on Nov. 17, 1942. It is not an important discovery.

Buck Snag, Colorado County.—Shell Oil Company's No. 1 C. R. Schiurring et al. was completed Sept. 4, 1942, from a Yegua sand, through perforations at 6143 to 6145 ft. for 100 bbl. 50.2° gravity oil and 2,706,000 cu. ft. of gas through ¼-in. choke, tubing pressure 2100 lb., total depth 6987 ft. There was no other development during 1942. Present information is not sufficient to determine the area or value of this discovery.

Cadiz, Bee County.—Wilcox Oil and Gas Company's No. 1 Homer Harris was drilled to total depth of 4717 ft. in shale, where Schlumberger tests were run followed by a series of side-wall cores and drill-stem tests. The well was completed Apr. 30, 1942, from 3734 to 3739 ft. for 14,000,000 cu. ft. of gas through open flow. The well is now shut in; shut-in pressure, 1450 lb. The same operators' No. 2 Homer Harris is the only additional development to date. The No. 2 well was completed as a gas well from 3760 to 3763 ft. Both wells are completed in the Jackson. Subsurface geology was the method of discovery. It is not important.

Camp Eleven, Tyler County.—American Republic and Houston Oil Company's No. 1 E. Cushing Fee was completed from the Wilcox Jan. 15, 1942, at 8000 to 8010 for 612 bbl. of 44.8° gravity oil through ¼-in. choke. Two other wells were drilled during the year, one of which was dry. The Camp Eleven discovery is the result of geophysical work. Present information is not sufficient to determine its importance.

Cistern, Fayette County.—Continental Oil Company's No. 1 F. Gobitzsch was completed in the Wilcox at 2808 to 2814 ft. for 1,254,000 cu. ft. of gas through ¼-in. choke. The hole was bottomed at 4830 ft. in the Midway. No other wells drilled during 1942. This discovery is the result of geophysics. It is unimportant.

Collier, Jackson County.—The Texas Company's No. 2 O. D. Collier made 202 bbl. of 23.6° gravity oil from the Miocene at 2433 to 2455 ft. Total depth, 2455 ft. The same company's No. 1 Bettie Bonham was dry and abandoned at 3177. No other development during 1942. The discovery well was completed on Nov. 16, 1942. It is unimportant.

Hampton, Hardin County.—American Republic Corporation and Houston Oil Company completed their No. 1 Hampton Fee on July 19, 1942, in a Cockfield sand at 6949 to 6954 ft. for 517 bbl. of 40.4° gravity oil. The same company's No. 2 Hampton Fee was abandoned as dry at 7018 ft. in the Cockfield-Yegua section. There was no other development during 1942. Geophysics indicates this structure to be of the deep-seated dome type. At present it is difficult to evaluate, since the trend position is favorable for additional exploration of deeper horizons.

Harmon, Jackson County.—Gulfboard and Salt Dome's No. 1-A J. E. Harmon, the discovery well of the Harmon field, was completed May 1, 1942, at 5366 to

5377 ft. in a Frio sand for 104 bbl. of 28.8° gravity oil. Total depth, 6717 ft. Eleven wells were completed by the end of 1942. Only one, the Sun Company's No. 2 J. E. Harmon, failed. The Gulfboard and Salt Dome's No. 2 W. W. McCrory was recorded as a dual completion. Casing was perforated in two separate sands, 5322 to 5332 ft. oil sand, initial production 133 bbl., and 5394 to 5402 ft. gas sand, initial production gas, no gauge. The Harmon field is a south extension of the Ganado structure.

Mayo, Jackson County.—John Mayo opened the Mayo field Jan. 7, 1942, with his No. 1 A. C. Rodesney. The well was drilled to 7808 ft. in Vicksburg and plugged back, where it was completed in a Frio sand through perforations at 5408 to 5414 ft. for 115 bbl. of oil through ⅛-in. choke. To the end of the year, 22 wells had been

TABLE 2.—*Summary of Drilling Operations in Texas Gulf Coast*

Important Wildcats Drilled in 1942

	County	Survey	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested
1	Austin	Vital Flores	10,104	Lissie	Wilcox
2	Austin	Geo. T. Allen A364, Sec. 180	11,505	Lissie	Wilcox
3	Bee	Thos. Simmons	10,561	Goliad	Wilcox
4	Bee	C. Rivas Gr.	4,717	Goliad	Jackson
5	Bee	Garrett Roache A59	5,320	Lissie	Vicksburg
6	Bee	R. C. Ballard	7,010	Goliad	Wilcox
7	Bee	P. B. McEarly A236	7,507	Lagarto	Wilcox
8	Bee	H. H. Williams	4,750	Beaumont	Vicksburg
9	Brazos	E. M. Millican	3,559	Jackson	Wilcox
10	Colorado	I. & G. N. Sur. No. 6	6,997	Lissie	Yegua
11	Colorado	Francis Mayhar	11,497	Lissie	Wilcox
12	Dewitt	Willis A. Moore	8,500	Reynosa	Wilcox
13	Dewitt	James Kimberling	9,150	Reynosa	Wilcox
14	Fayette	J. Whiteside	4,340	Claiborne	Midway
15	Fort Bend	F. Mading	5,263	Beaumont	Frio
16	Hardin	A. Hampton Lge.	6,954	Lissie	Cockfield, Yegua
17	Harris	Peter F. Craft	7,991	Beaumont	Yegua
18	Harris	Christian Williams	8,637	Beaumont	Cook Mountain
19	Harris	Francis Fry	8,050	Beaumont	Cook Mountain
20	Jackson	James Kerr A39	2,455	Beaumont	Miocene
21	Jackson	A. Kountze No. 23	6,717	Beaumont	Frio
22	Jackson	J. Rambo	7,808	Lissie	Vicksburg
23	Jackson	W. H. Robertson	5,553	Beaumont	Frio
24	Jackson	Wm. Menefee	6,651	Beaumont	Frio
25	Jackson	Geo. Southerland	6,523	Beaumont	Frio
26	Jackson	Morris & Cumming	6,753	Beaumont	Frio
27	Jackson	G. F. & M. T. Simons	6,700	Beaumont	Frio
28	Jackson	Jos. Simons	6,700	Beaumont	Frio
29	Jackson	I. G. N. Survey No. 3	7,735	Beaumont	Vicksburg
30	Jackson	I. G. N. Survey No. 1	6,504	Beaumont	Frio
31	Jackson	Patrick Scott Lge.	7,620	Beaumont	y
32	Jackson	I. G. N. Survey No. 19	5,946	Beaumont	Frio
33	Jackson	Geo. Southerland	5,155	Beaumont	Frio
34	Jackson	S. F. Austin Grant	5,762	Beaumont	Frio
35	Jackson	S. F. Austin 2 Lge. Grant	6,763	Beaumont	Frio
36	Jefferson	T. & N. O. A371	9,300	Beaumont	Frio
37	Jefferson	T. & N. O. A371	9,500	Beaumont	Frio
38	Liberty	Jesse Devore	6,958	Beaumont	Yegua
39	Liberty	Jesse Devore	6,300	Beaumont	Yegua
40	Matagorda	Jacob Betts Lge.	8,692	Beaumont	Frio
41	Matagorda	G. B. M. Cotton	8,598	Beaumont	Frio
42	Matagorda	Elisha Hall	9,121	Beaumont	Frio
43	Montgomery	M. R. Goheen	12,259	Willis	Wilcox
44	Montgomery	A. Hodge	13,293	Willis	Wilcox
45	Polk	A. Viesca	7,993	Lagarto	Wilcox
46	Polk	A. Viesca	7,396	Lagarto	Wilcox
47	Refugio	Aldrete Gr.	7,656	Beaumont	Frio
48	Refugio	Refugio Town Tract	9,375	Beaumont	Frio
49	San Jacinto	Jas. Robinson	8,321	Lagarto	Wilcox
50	Tyler	Theo. Cushing	8,035	Lissie	Wilcox
51	Tyler	T. Cushing Lge.	8,450	Lissie	Wilcox

drilled, one of which was dry and one a gas well. The Mayo field is an east extension of the Ganado structure.

Medio Creek, Bee County.—The Shield Oil Company's No. 1 Ira Heard on a 24-hr. potential test through open flow made 36,000,000 cu. ft. of gas. On 24-hr. test through a 5/16-in. choke the well made 3,821,600 cu. ft. of gas and 6 bbl. of 40.8° gravity oil from a Frio-Vicksburg sand at 4855 to 4865 ft. The well was completed on March 3, 1942, as a shut-in gas well. The same company's No. 2 Ira Heard was a dry hole to 5500 ft. There was no other development during 1942. It is not an important discovery.

Mercy, San Jacinto County.—Shell Oil Company completed its No. 1 Central Coal and Coke Corporation Feb. 3, 1942, in a Wilcox sand at 8273 to 8279 ft. for

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1942

	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.		Remarks
		Oil, U. S. Bbl.	Gas, Millions Cu. Ft.		Casing	Tubing	
1	Ohio Oil Co.	105	8,757,000	½	2,350	1,500	D. Orange Hill field
2	Shell Oil Co.	80.1		5/16	2,950	2,710	D. Sealy field
3	Magnolia Petr. Co.	8.5	328,000	3/16	1,175	725	D. Berclair field
4	Wilcox Oil & Gas Co.		14,000,000	Open	1,140	1,080	D. Cadis field
5	Shield Oil Co.	6	3,821,000	5/16	1,960	1,825	D. Medio Creek field
6	Union Producing Co.	37.5		18/64	2,500	2,425	N. H. North Pettus field
7	Atlantic Ref. Co.	127		⅛	2,200	1,800	D. South Caesar
8	Stanolind Oil & Gas Co.	41		5/32	1,700	1,300	D. Tynan field
9	Phillips Petr. Co.		10,150,000	Open	Sealed	1,335	D. Millican field
10	Shell Oil Co.	100		¼	2,250	2,150	D. Buck Snag field
11	Shell Oil Co.	135		¼	2,400	2,320	N. H. Sheridan field
12	Tide Water Asso. Oil Co.	80		7/64	Sealed	1,080	D. Nordheim field
13	Adams Oil & Gas Co.	146		⅜	y	y	D. Yorktown
14	Continental Oil Co.		3,850,000	5/32	y	840	D. Cistern field
15	W. L. Goldston	232		¼	825	200	N. H. Needville field
16	Amer. Rep. & Houston Oil Co.	517		¼	1,150	850	D. Hampton field
17	Geo. Strake	36			Sealed	2,000	D. West Aldine field
18	Pure Oil Co.	54	3,335,000	29/64	1,005	1,255	D. Alief field
19	Amerada Petr. & Stanolind	160		⅛	Sealed	1,150	N. H. Satsuma field
20	The Texas Company	202		11/64	360	295	D. Collier field
21	Gulf Board & Salt Dome Oil Co.	104		5/32	Sealed	340	D. Harmon field
22	John Mayo	115		⅛	575	525	D. Mayo field
23	W. Stewart Boyle	155		9/64	1,700	1,300	N. H. Mayo field
24	Renwar Oil Corp.	113		⅛	2,500	1,960	D. Mustang Creek field
25	W. Stewart Boyle	148		⅛	1,900	1,300	D. Stewart field
26	John B. Coffee	78		⅛	1,450	500	D. West Maurits field
27	Humble Oil Ref. Co.	130		⅛	900	800	N. H. Ganado field
28	The Texas Company	112		⅛	Sealed	775	N. H. Ganado field
29	Magnolia Petr. Co.	126		9/64	2,100	300	N. H. North La Ward field
30	Magnolia Petr. Co.	9		3/16	2,250	2,375	N. H. North La Ward field
31	Magnolia Petr. Co.		No gauge				N. H. North La Ward field
32	Tide Water Asso. Oil Co.	121		⅛	900	625	N. H. Lotita field
33	W. Stewart Boyle	50		5/32	Sealed	1,275	N. H. Stewart field
34	Houston Oil Co. of Texas		49,000,000	Open			N. H. Texana field
35	Moore & Ahern	8	1,300,000	¼	2,225	2,200	N. H. Texana field
36	Glenn H. McCarthy	793		¼	Sealed	1,000	N. H. Stowell field
37	Sinclair Prairie Oil Co.	388		¼	Sealed	2,075	N. H. Stowell field
38	South Oil Co.	315		⅛	Sealed	1,240	N. H. Hull field[1]
39	South Oil Co.	302		¼	Sealed	2,000	N. H. Hull field[1]
40	Ohio Oil Co.	309		⅛	1,375	1,210	D. North Bay City
41	United North & South Dev. Co.	243		13/64	600	500	N. H. Buckeye field
42	Stanolind Oil & Gas Co.	232		¼	1,550	250	N. H. Lucky field
43	Superior of California	213		¼	Sealed	2,850	N. H. Lake Creek field
44	Superior of California	160		23/64	Sealed	1,700	N. H. Lake Creek field
45	Gem Oil Co.	207		¼	900	200	N. H. Livingston field
46	Jordan Drilling Co.	216		¼	1,600	225	N. H. Livingston field
47	Hewitt & Dougherty	357		3/16	1,460	1,210	D. Rooke field
48	Sunray Oil Co.	225		¼	Sealed	3,250	N. H. Mission River field
49	Shell Oil Co.	583		¼	1,620	860	D. Mercy field
50	Amer. Republic & Houston Oil	612		¼	1,750	1,350	D. Camp Eleven field
51	Amer. Republic & Houston Oil	30		⅛	1,850	1,775	D. Ramers Island field

[1] New horizon for northwest flank.

583 bbl. of 38° gravity oil through ¼-in. choke. Out of a total of 15 wells drilled during 1942 only one was abandoned as dry. In view of the erratic characteristics of the Wilcox section, the Mercy field appears to be as good as any thus far discovered. The producing section in the discovery well, 8275 to 8280 ft., averages 17 per cent porosity and 11 to 15 per cent saturation. Permeability figures are not available. The discovery is the result of geophysical work by the Shell Oil Company.

Millican Dome, Brazos County.—Phillips Petroleum Co. drilled No. 1 Fritz Jerichow to 3559 ft. in salt-water sand. After numerous tests that showed various amounts of gas and/or salt water, the well was sidetracked and completed on May 22, 1942, in a Wilcox sand at 3342 to 3348 ft. for 10,150,000 cu. ft. gas through open flow. Prior to the discovery well Phillips drilled two other wells, both of which were abandoned in dome material. There has been no other development during 1942. Not

TABLE 3.—*Field Wells in 1942, by Counties*

County	Production, Bbl.	Number Producing Wells	Wells Drilled During 1942		
			Total Number	Gas and Oil	Dry
UPPER TEXAS GULF COAST					
Austin	1,587,510	160	4	2	2
Brazoria	19,369,790	1,214	27	20	7
Brazos					
Burleson					
Chambers	8,616,989	687	37	35	2
Colorado	82,217	6	1	1	
Fayette			1	1	
Fort Bend	6,669,379	487	18	15	3
Galveston	3,653,126	293	7	6	1
Hardin	1,672,041	596	14	6	8
Harris	13,878,307	1,601	30	22	8
Jasper	2,693				
Jefferson	5,799,526	509	42	34	8
Liberty	4,802,422	505	19	16	3
Matagorda	1,719,525	153	18	13	5
Montgomery	13,514,872	937	18	11	7
Newton					
Orange	1,055,265	122	6	3	3
Polk	1,943,228	202	5	4	1
San Jacinto	159,324	7	11	10	1
Tyler	840,845	46	6	4	2
Waller			8	8	
Washington	143,659	56			
Wharton	5,829,774	567	84	80	4
Total	91,340,492	8,148	356	291	65
LOWER TEXAS GULF COAST					
Aransas	8,232	1	2	1	1
Bee	476,594	237	25	16	9
Calhoun	2,993,678	243	3		3
Dewitt	1,044				
Goliad	32,840	13	2	1	1
Jackson	9,913,571	842	231	209	22
Karnes	40,826	25			
Lavaca			2	2	
Live Oak	424,271	73	16	11	5
Refugio	11,067,664	1,023	29	24	5
Victoria	1,710,239	270	22	19	3
Total	26,668,959 91,340,492	2,727 8,148	332 356	283 291	49 65
Grand total	118,009,451	10,875	688	574	114
During 1941	113,726,893		1,405	1,081	324

much is expected of this structure as an oil producer. Geophysics was the method of discovery.

TABLE 4.—*Fields that Produced One Million Barrels or More of Crude Oil during* 1942 *on the Texas Gulf Coast*

Field	County	Year Discovered	1942 Production	Producing Formation
Conroe	Montgomery	1931	13,499,571	Yegua
Hastings	Brazoria	1934	10,431,616	Frio
Tom O'Connor	Refugio	1934	6,914,652	Frio
Thompson (combined)	Fort Bend	1931	5,390,089	Miocene, Frio, Vicksburg
West Ranch	Jackson	1938	5,243,272	Frio
Magnet-Withers	Wharton	1936	4,195,632	Frio
Old Ocean	Brazoria	1934	3,728,036	Frio
Friendswood	Harris	1937	3,619,963	Frio
Anahuac	Chambers	1935	3,587,642	Frio
Tomball	Harris	1933	3,114,943	Yegua
Heyser	Calhoun	1936	2,926,870	Frio
Barbers Hill	Chambers	1916	2,861,740	Miocene-Frio
Fairbanks	Harris	1938	2,645,881	Yegua
Lolita	Jackson	1940	2,258,006	Frio
Hull	Liberty	1918	2,237,982	Mio, Frio, Vicks, Yeg, Cook Mt.
West Columbia	Brazoria	1919	1,989,993	Miocene, Frio
Manvel	Brazoria	1931	1,910,144	Miocene, Frio
Lovells Lake	Jefferson	1938	1,797,114	Frio
Gillock	Galveston	1934	1,772,099	Frio
Raccoon Bend	Austin	1927	1,587,510	Jackson, Yegua
Amelia	Jefferson	1938	1,380,083	Frio
Segno	Polk	1931	1,280,423	Yegua, Wilcox
Refugio	Refugio	1920	1,247,779	Frio
Greta	Refugio	1933	1,173,316	Frio
Placedo	Victoria	1935	1,132,952	Frio
Hardin	Liberty	1935	1,067,318	Yegua

Mustang Creek, Jackson County.—Renwar Oil Corporation's No. 1 O. W. Freeman was completed Nov. 20, 1942, in a Frio sand at 6644 to 6648 ft. for 113 bbl. of 31.1° gravity oil through ⅛-in. choke. Total depth, 6651 ft. The Renwar Corporation's No. 1 Camille Smith was abandoned at 6762 ft. on Dec. 14, 1942, after having cored only slight shows in the Frio zone. No other wells were drilled during 1942. The importance of this field is as yet undetermined. Discovery was the result primarily of trend development.

Nordheim, Dewitt County.—Tide Water Associated Oil Company's No. 1 E. G. Gips was completed on Sept. 3, 1942, from a Wilcox sand at 7027 to 7030 ft. for 35.5 bbl. of 40° gravity oil and 34.5 bbl. of salt water through 3/32-in. choke. Several other possible producing horizons were tested between 7118 and 8344 ft., which showed various amounts of high-gravity oil and gas or high-gravity oil, gas and salt water. The well was bottomed at 8500 ft. in Wilcox. No other development occurred during 1942. Additional development is necessary for any reasonable estimate of the merits of this prospect.

North Bay City, Matagorda County.—Ohio Oil Co. opened the North Bay City field on Aug. 22, 1942, with the completion of its No. 1 E. L. McDonald (Account No. 1) in a Frio sand at 7870 to 7873 ft. for 309 bbl. of 34.4° gravity oil through ⅛-in. choke. The well was bottomed at 8692 ft. in shale. Four wells were drilled during 1942, three by the Ohio Oil Co. and one by the Sun Oil Co., all producers. The discovery of the North Bay City field is the result of geophysical work by Ohio Oil Company.

North Withers, Wharton County.—The North Withers field, Wharton County, reported as a 1942 discovery, actually is part of the Magnet-Withers producing area. Recent division of this area into fields, Magnet, Withers and North Withers, indicates that the discovery well of the North Withers field was drilled during 1940 in what was then known as the Withers field. For convenience, and to avoid possible repetition, all statistical data in this report have been listed under Magnet-Withers.

Orange Hill, Austin County.—The Ohio Oil Co. completed its No. 1 First National Bank of Galveston well on Nov. 8, 1942, in Wilcox sands at 9052 to 9067 and 9080 to 9145 ft. for an initial production of 105 bbl. of 44.8° gravity oil plus 17 per cent brackish water and 8,757,000 cu. ft. gas through ½-in. choke. The well was bottomed at 10,104 ft. in Wilcox. Geophysics was the method of discovery. There was no other development during 1942.

Ramers Island, Tyler County.—American Republic Corporation and Houston Oil Co. completed their No. 1-R Cushing Fee Apr. 4, 1942, through perforations at 5397 to 5400 ft. in a Yegua sand, for 28 bbl. of 48.1 gravity oil. The same operators' No. 2-R Cushing failed to establish production in the Wilcox to 8454 ft. After sidetracking, the well was abandoned at 5430 ft. when it failed to produce oil in commercial quantities from the Yegua zone. The Ramers Island discovery is the result of geophysical work. It does not appear to be particularly important at this time. There was no other development to the end of 1942.

Rooke, Refugio County.—Hewitt and Dougherty discovered the Rooke field Apr. 1, 1942, when their No. 6-A Rooke-Wagner was completed in a Frio sand at 7135 to 7139 ft. for 357 bbl. of 37.5° gravity oil. Development during 1942 consisted of three oil wells and one dry hole. The Rooke area does not appear to be of major importance. Subsurface geology was the method of discovery.

Sealy, Austin County.—After drilling to 11,505 ft. in hard, sandy shale, the Shell Oil Co. completed its No. 1 Hintz in Wilcox sands, through perforations at 8724 to 8742, 8747 to 8753 and 8760 to 8787 ft. for an initial production of 80.1 bbl. of 48.9° gravity oil through 5⁄16-in. choke; gas-oil ratio 75,280 to 1, gas volume 22,000,000 cu. ft. per day, on open-flow back-pressure test. Shut-in pressure, 3200 lb. The well was completed June 4, 1942. Shell Oil Co. has unitized its holdings into 160-acre drilling units. The discovery is the result of reflection seismograph work. The No. 1 Hintz, which is the only well, does not furnish sufficient information for an evaluation of the Sealy field.

South Caesar, Bee County.—Atlantic Refining Company's No. 1-A J. J. Grissom was completed Feb. 10, 1942, in a Wilcox sand at 6552 to 6557 ft., for 127 bbl. of 42° gravity oil through ⅛-in. choke. The well was bottomed in Wilcox at 7507 ft. During the year, 18 wells were drilled, 13 produced oil, 5 were abandoned as dry. South Caesar is not considered a major discovery.

Stewart, Jackson County.—W. Stewart Boyle, Tr. No. 1 E. T. Rose was drilled to 6523 ft. in shale. After running electric log the well was plugged back and completed on July 23, 1942, for 148 bbl. of 49.3° gravity oil at 4985 to 4996 ft. in the Marginulina-Frio zone. To the end of 1942, nine wells were drilled, five producers, three dry holes and one listed as temporarily abandoned. Stewart appears to be a west extension of the Ganado structure, separated from Ganado proper by a small fault. It is not an important discovery.

Tynan, Bee County.—Stanolind Oil and Gas Company's No. 1 Mrs. L. Ulke was drilled to 4750 ft. in shale and was plugged back and perforated in a Frio-Vicksburg sand at 4212 to 4213 ft. On a 6-hr. potential test the well made 28 bbl. of fluid, 40 per cent oil and 60 per cent salt water. On Dec. 18, 1942, the well was completed for 41 bbl. net of 23° gravity oil through 5⁄32-in. choke. The Tynan discovery is unimportant.

West Aldine, Harris County.—George W. Strake completed No. 1 Phenix Dairy

Apr. 3, 1942, in a Yegua sand at 7190 to 7193 ft. for 36 bbl. of 39.6° gravity oil and 9.5 bbl. of salt water. The well was drilled to a total depth of 7991 ft. in shale. No other wells drilled during 1942. It is not an important discovery.

West Mauritz, Jackson County.—Jno. B. Coffee completed No. 1 Mauritz Bros. Apr. 21, 1942, for 78 bbl. of 33.8° gravity oil at 5747 to 5762 in a Frio sand. Coffee No. 3-B Mauritz made distillate from perforations at 5409 to 5415 and 5596 to 5598 ft. Five wells are producing from 5450 to 5488 ft. The three other wells drilled during 1942 were dry holes. The West Mauritz field is a southeast extension of the Ganado structure; otherwise it is not important.

Yorktown, Dewitt County.—Adams Oil and Gas Co., after drilling its No. 1 E. Berck to 9150 ft. in shale, completed it Apr. 2, 1942, in a Wilcox sand at 7192 to 7204 ft. for 146 bbl. of 62.8° gravity oil and 6,000,000 cu. ft. of gas through ⅜-in. choke. Marshall Purvis et al. abandoned their No. 1 H. Afflerback Nov. 17, 1939, at 7669 ft. in Wilcox sand. There was no other development to the end of 1942. The discovery is unimportant.

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Oil and Gas Development and Production in North Texas for the Year 1942

By Lewis W. MacNaughton,* Member A.I.M.E., and R. B. Gilmore†

The North Texas district, as herein defined, includes the counties of Archer, Baylor, Clay, Cooke, Foard, Hardeman, Knox, Montague, Wichita, and Wilbarger. This area covers generally the crest and south flank of a system of buried mountains known as the Red River uplift. The oil and gas accumulations along this feature are in traps, which, although localized by structures incident to the regional uplift, usually are modified by stratigraphic changes in the sediments. Excepting those in southeastern Baylor, southern Archer, and southwestern Clay counties, all the fields within the district are on this Red River uplift. These exceptions, which have the same type of oil and gas accumulation as the other fields, are on the extreme north end of the Bend arch, which is a broad anticline plunging northward from the Llano uplift in central Texas to Archer County. The larger part of past oil and gas production has come from Pennsylvanian strata, with less important amounts from the Permian, and minor but increasingly important quantities from the Ordovician.

DEVELOPMENTS DURING 1942

Approximately 500 wells were drilled in the district during 1942, in contrast with some 1600 wells drilled during 1941, and only some 300 oil wells were completed, a decrease from 1941 of more than 10 per cent in the number of successful drilling operations of the total wells drilled.

Production increased slightly over the previous year in spite of a decrease in the number of producing wells. The average depth of discovery wells was some 600 ft. deeper than in 1941. Although more discoveries produced from horizons above the base of the Strawn series than those below the Strawn, the deeper horizons, including the Bend series of the Pennsylvanian, the Mississippian limestone, and the Simpson and Ellenburger of the Ordovician, furnished most of the addition to oil reserves.

The largest single addition to the reserves was again in the Ellenburger formation in the K. M. A. field. During the year 47 wells were completed, bringing the total developed acreage in this horizon to some 5450 acres. The most active area was Montague County, in which eight fields, or potential fields, were discovered although only 39 oil wells were completed.

K. M. A. Pressure Maintenance

Satisfactory progress was made by the K. M. A. Pressure Maintenance Association in 1942. At the end of the year, 100 wells were being used for input and total monthly volume of gas returned to the reservoir reached a high of 430,971 M cu. ft. in December, with an input ratio of 587 cu. ft. of gas returned for each barrel of oil produced during the month. This represents a utilization of 50 per cent of the gas available for return during that month.

Comparison of the present average bottom-hole pressure by means of a decline

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TABLE 1.—*Oil and Gas Production in North Texas District*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells				
							During 1942		End of 1942	
			Oil[b]	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]
	Archer County:									
1	Blewett	1940	100	82,630	35,048	12	1	0	0	12
2	Browning	1942	40	2,543	2,543	1	1	0	0	1
3	Chalk Hill—deep	1931	600	3,106,976	75,169	*y*	0	1	0	35
4	Colgan	1939	100	86,110	33,854	9	0	0	0	9
5	Cooper	1942	40	6,593	6,593	1	1	0	0	1
6	Hull-Silk	1938	7,000	11,110,942	3,990,038	443	2	4	0	441
7	Kadane—deep	1939	400	329,780	184,922	19	2	0	0	19
8	Kadane—shallow	1939	80	59,783	40,525	9	1	0	0	9
9	Mankins	1939	500	587,152	191,834	14	0	0	0	14
10	McCrory	1938	20	39,503	6,421	1	0	0	0	1
11	Meade	1940	50	19,563	6,119	7	0	0	0	7
12	Pan-Taylor	1941	40	3,511	1,580	1	0	0	0	1
13	Moer	1938	20	20,953	3,244	1	0	0	0	1
14	Scotland	1940	800	337,525	255,892	26	9	0	0	26
15	Vogtsberger	1940	120	79,576	36,897	3	0	0	0	3
16	All other fields	1911	*y*	122,109,079	2,725,428	*y*	30	*y*	*y*	3,272
	Total Archer County		*y*	137,982,219	7,596,107	76*yy*	47	*y*	*y*	3,852
	Archer and Wichita Counties:									
17	Jackson	1938	300	241,341	36,614	22	0	0	0	22
	Baylor County:									
18	Portwood	1924	600	4,968,568	154,319	188	0	17	0	127
19	Rendham	1940	560	148,337	82,842	14	2	1	0	13
20	Seymour	1939	1,480	902,599	358,489	33	0	1	0	32
	Total Baylor County		2,640	6,019,504	595,650	235	2	19	0	172
	Clay County:									
21	Antelope	1939	850	712,027	432,188	52	2	0	0	52
22	Antelope—Mississippi	1941	80	40,183	27,029	2	1	0	0	2
23	Apache[1]	1940	40	3,835	467	2	0	2	0	0
24	Boddy	1938	300	152,688	110,190	33	0	0	0	33
25	Burns-Browning	1939	320	188,686	47,564	5	0	0	0	5
26	Costley	1939	40	64,686*y*	16,455	12	2	0	0	12
27	Edrington	1932	500	1,309,470*y*	183,430	119	3	1	0	118
28	Halsell	1939	500	352,701	147,813	11	2	0	0	11
29	Hapgood	1940	120	129,440	56,210	3	0	0	0	3
30	Howard	1940	40	12,912	3,851	1	0	0	0	1
31	Joy	1940	240	129,293	126,233	6	5	0	0	6
32	Kinder	1939	40	10,284	2,058	1	0	0	0	1
33	Knox-Finley	1923	700	630,546*y*	214,558	111	5	1	0	110
34	McInniss	1940	400	402,650	192,842	78	11	1	0	76
35	Nebraska	1922	100	[2]	21,381	3	0	0	0	2
36	New York City	1941	400	157,075	123,654	10	5	0	0	10
37	Petrolia	1902	3,000	[2]	88,077	9*yy*	1	*y*	*y*	382
38	Ross	1939	800	243,531	146,578	20	8	0	0	20

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Field abandoned, 1942.

[2] Included in county total.

TABLE I.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells		Gravity A.P.I. at 60°F. Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
	Flowing	Artificial Lift						Top Prod. Zone	Bottoms Prod Wells				
1	0	12	38	Cisco	Pen	S	Por	1,425	1,450	*y*	ML	Cisco	1,557
2	1	0	41	Ellenburger	Ord	DL	Por	5,321	5,330	*y*	*y*	Ellenburger	5,330
3	0	35	42	Canyon Strawn	Pen Pen	S S	Por Por	2,200 3,600	2,225 3,640	20	A	Ellenburger	5,748
4	0	9	40	Cisco	Pen	S	Por	1,453	1,461	8	MC	Cisco	1,500
5	1	0	43	Detrital	*y*	DCgl	Por	4,888	4,903	*y*	*y*	Ellenburger	5,028
6	185	256	43	U. Strawn M. Strawn L. Strawn Bend	Pen Pen Pen Pen	S L S L	Por Por Por Por	3,800 3,980 4,280 4,620	3,860 4,050 4,380 4,630	15 12 30 10	A	Ellenburger	5,272
7	14	5	42	Strawn	Pen	S	Por	4,337	4,351	10	A	*y*	4,901
8	0	9	42	Cisco	Pen	S	Por	1,630	1,640	8	AM	*y*	4,901
9	7	7	43	Bend	Pen	L	Por	4,660	4,690	30	A	*y*	4,918
10	0	1	41	Bend	Pen	L	Por	4,735	4,760	20	N	*y*	5,159
11	0	7	38	Cisco	Pen	S	Por	954	960	5	*y*	Cisco	1,407
12	0	1	*y*	Chappel	Mis	L	Por	4,927	4,949	*y*	*y*	Mississippi	5,051
13	0	1	40	Strawn	Pen	S	Por	4,135	4,138	3	*y*	Ellenburger	5,433
14	21	5	42	Strawn Bend Chappel	Pen Pen Mis	S L L	Por Por Por	4,016 5,042 5,550	4,032 5,058 5,560	10 10 10	A	Ellenburger	5,850
15	2	1	41	Strawn	Pen	S	Por	4,656	4,671	15	*y*	Ellenburger	5,335
16	6	3,266											
	237	3,615											
17	0	22	*y*	Canyon	Pen	L	Por	2,600	2,630	10	*y*	Canyon	2,700
18	0	127	36	Gunsight	Pen	S	Por	1,340	1,400	*y*	ML	Strawn	4,265
19	1	12	31	Canyon	Pen	L	Por	3,025	3,060	*y*	M	Strawn	4,326
20	0	32	36	U. Canyon	Pen	L	Por	2,525	2,605	20	N	Ellenburger	5,598
	1	171											
21	49	3	40	Strawn Bend	Pen Pen	S L	Por Por	3,190 5,451	3,250 5,480	25 *y*	AM	Ellenburger	6,100
22	2	0	40	Chappel	Mis	L	Por	5,670	5,760	*y*	AM	Ellenburger	6,100
23	0	0	*y*	Cisco	Pen	S	Por	1,125	1,140	*y*	N	Cisco	1,366
24	0	33	*y*	Cisco	Pen	S	Por	1,050	1,120	10	ML	Cisco	1,330
25	1	4	44	Strawn	Pen	S	Por	4,430	4,460	20	A	Ellenburger	6,014
26	0	12	40	Cisco	Pen	S	Por	1,035	1,160	18	ML	Cisco	1,406
27	0	118	38	*y* Cisco	Per Pen	S S	Por Por	325 1,090	350 1,120	15	N	*y*	2,064
28	4	7	40	U. Strawn M. Strawn Bend	Pen Pen Pen	S S L	Por Por Por	3,656 4,720 5,432	3,663 4,800 5,444	*y*	A	Ellenburger	6,048
29	3	0	45	Bend	Pen	Cgl	Por	5,972	6,033	20	A	Ellenburger	6,538
30	0	1	44	Bend	Pen	L	Por	5,460	5,488	15	*y*	Bend	5,606
31	6	0	45	Strawn Chappel	Pen Mis	S L	Por Por	3,950 5,905	3,975 5,967	*y*	*y*	Ellenburger	6,209
32	0	1	37	Strawn	Pen	S	Por	4,130	4,150	15	*y*	Bend	5,527
33	0	110	*y*	*y* Cisco	Per Pen	S S	Por Por	280 1,110	300 1,145	10	A	Cisco	1,716
34	0	76	*y*	*y* Cisco	Per Pen	S S	Por Por	250 1,070	260 1,120	10	A	Cisco	1,404
35	1	1	*y*	Bend	Pen	L	Por	5,777	5,790	10	N	Ellenburger	6,098
36	9	1	45	Strawn Chappel	Pen Mis	S L	Por Por	4,911 6,180	4,925 6,280	*y*	*y*	Ellenburger	6,837
37	0	382	30	*y* Cisco	Per Pen	S S	Por Por	230 760 1,000 1,720	300 780 1,020 1,780	12 10 10 15	A	Pre-Cambrian	4,289
38	19	1	46	Bend	Pen	L	Por	5,350	5,400	40	AM	Ellenburger	5,846

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells				
							During 1942		End of 1942	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]
	Clay County:									
39	Shumake	1937	550	673,847	146,535	81	3	0	0	81
40	Spring	1941	80	63,330	62,521	2	1	0	0	2
41	Taylor	1940	275	286,325	180,176	59	8	1	0	58
42	Watson	1942	500	34,541	34,541	10	10	0	0	10
43	Worsham	1923	200	[2]	26,397	13	0	0	0	7
44	Wright-Barry	1926	60	[2]	1,872	11	0	0	0	5
	Total Clay County		10,135	13,226,719	2,392,620	15*yy*	67	*y*	*y*	1,007
	Cooke County:									
45	Anderson	1935	880	3,835,839	309,900	128	1	0	0	124
46	Big Indian	1924	20	[2]	2,548	2	0	0	0	1
47	Bindel	1941	60	48,817	30,296	6	0	0	0	6
48	Bulcher	1926	580	[2]	203,736	168	1	3	0	145
49	Huggins	1929	160	[2]	5,327	30	0	4	0	17
50	Muenster	1926	1,900*y*	[2]	715,076	6*yy*	7	*y*	0	607
51	Osburn	1941	10	4,728	4,149	1	0	0	0	1
52	Pilot Point	1930	80	[2]	1,058	*y*	0	0	0	2
53	Talbott	1936	40	34,529	4,090	6	0	0	0	4
54	T. C. U.	1939	300	154,469	60,219	53	1	1	0	50
55	Trew	1936	300	899,481	63,311	49	0	0	0	49
56	Voth	1938	650	591,657	163,331	62	0	3	0	59
57	Walnut Bend	1938	1,500	3,890,942	1,256,474	130	6	0	0	130
58	Wheelock	1928	100	85,177*y*	3,692	11	0	0	0	8
59	Wilson	1941	140	37,426	27,010	8	2	1	0	7
	Total Cooke County		6,720*y*	25,823,701	2,850,217	*y*	18	*y*	0	1,210
	Foard County:									
60	Allee[1]	1940	120	17,353	19	5	0	3	0	0
61	Johnson	1933	380	1,695,785	73,034	16	0	1	0	10
62	Thalia	1927	180	339,195	11,711	13	0	0	0	5
	Total Foard County		680	2,052,333	84,764	34	0	4	0	15
	Montague County:									
63	Beck	1933	260	2,052,950*y*	102,517	67	1	2	0	53
64	Benson	1941	100	45,207	29,452	4	2	0	1	3
65	Bonita	1940	380	616,836	235,614	20	0	0	0	20
66	Bowers	1939	800	720,865	338,035	36	4	0	0	32
67	Chapman and McFarlin	1941	20	25,715	21,440	1	0	0	0	1
68	Clingingsmith	1941	160	90,701	67,147	5	1	0	0	5
69	Forestburg	1942	300	95,211	95,211	7	7	0	0	7
70	Hildreth	1942	40	4,963	4,963	1	1	0	0	1
71	Holt	1936	240	789,270	63,771	37	0	0	0	37
72	Hults and Owens	1940	80	81,052	43,427	5	1	1	0	2
73	Mueller	1942	100	28,971	28,971	2	2	0	0	2
74	Nocona	1918	3,200	30,743,795*y*	1,113,569	950*y*	0	15*y*	*y*	809
75	Ringgold	1940	520	371,061	172,187	13	4	0	0	1[illegible]

TABLE 1.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells		Gravity A.P.I. at 60°F. Weighted Average					Depth, Avg. Ft.					
	Flowing	Artificial Lift		Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
39	0	81	*y*	Cisco	Pen	S	Por	1,130	1,200	15	ML	Cisco	1,945
40	1	1	48	Bend	Pen	L	Por	5,588	5,630	*y*	*y*	Ellenburger	6,262
41	1	57	*y*	*y*	Per	S	Por	200	300	10	ML	Cisco	1,852
				Cisco	Pen	S	Por	1,120	1,150	15			
42	8	2	43	Strawn	Pen	S	Por	3,655	3,676	*y*	*y*	Ellenburger	6,051
				Bend	Pen	L	Por	5,452	5,483	*y*			
43	0	7	38	U. Strawn	Pen	S	Por	3,400	3,440	10	A	Ellenburger	6,220
				M. Strawn	Pen	S	Por	3,925	3,980	20			
				Bend	Pen	L	Por	5,588	5,669	*y*			
				Ellenburger	Ord	DL	Por	5,780	5,792	*y*			
44	0	5	*y*	Cisco	Pen	S	Por	840	860	*y*	ML	Strawn	4,112
	104	903											
45	0	124	41	Strawn	Pen	S	Por	1,605 1,950	1,615 1,970	10	AM	*y*	2,710
46	0	1	47	Strawn	Pen	S	Por	3,518	3,529	11	*y*	Strawn	3,919
47	1	5	38	Strawn	Pen	S	Por	1,885	1,896	10	A	Ellenburger	3,247
				Ellenburger	Ord	L	Por	3,242	3,247	5			
48	0	145	*y*	Strawn	Pen	S	Por	1,125	1,318	10	MC	*y*	2,042
				Ellenburger	Ord	L	Por	1,403	1,753				
49	0	17	*y*	Strawn	Pen	S	Por	1,150	1,190	10	N	*y*	2,001
50	0	607	29–37	Cisco	Pen	S	Por	707	800	10	A	Ellenburger *y*	1,960*y*
				Canyon	Pen	S	Por	990	1,282	*y*			
				Strawn	Pen	S & L	Por	1,585	1,600	15			
51	0	1	*y*	Strawn	Pen	S	Por	2,309	2,320	10	*y*	Strawn	2,320
52	0	2	25	Cisco	Pen	S	Por	1,502	1,523	*y*	N	Cisco	1,652
53	0	4	40	Strawn	Pen	S	Por	1,650	1,700	5	N	*y*	3,100
54	0	50	30	Strawn	Pen	S	Por	1,125	1,143	8	A	*y*	2,163
55	0	49	37	Strawn	Pen	S	Por	1,475	1,485	8	AM	Pennsylvanian	2,095
56	0	59	39	Ellenburger	Ord	L	Por	1,725	1,735	10	*y*	Ellenburger	1,793
57	4	126	34	U. Strawn	Pen	S	Por	4,108	4,895	7	N	*y*	6,110
				L. Strawn	Pen	S	Por	5,141	5,173	20			
				Simpson	Ord	L	Por	5,206	5,242	30			
				Ellenburger	Ord	L	Por	5,413	5,565	30			
58	0	8	*y*	*y*	Pen	S	Por	1,306	1,330	*y*	N	*y*	1,397
59	0	7	41	Strawn	Pen	S	Por	2,221	2,380	10	AM	Strawn	2,380
	5	1,205											
60	0	0	33	Canyon	Pen	L	Por	2,360	2,370	10	*y*	Canyon	2,370
61	0	10	50	Canyon	Pen	L	Por	3,600	3,625	*y*	A	Pre-Cambrian	5,003
62	0	5	39	Thalia	Pen	S	Por	*y*	*y*	*y*	A	Pre-Cambrian	2,550
				Cisco	Pen	L	Por	2,500	2,550				
	0	15											
63	0	53	39	Canyon	Pen	S	Por	1,480	2,330	*y*	AL	*y*	2,484
				Strawn	Pen	S	Por	2,471	2,484	*y*			
64	3	1	44	Bend	Pen	L	Por	5,840	5,850	10	*y*	Ellenburger	6,014
65	15	5	40	Strawn	Pen	S	Por	5,240	5,249	9	A	Ellenburger	6,975
				Bend	Pen	L	Por	5,443	5,458	15			
66	12	20	39	Canyon	Pen	L	Por	2,020	2,320	11	A	Pre-Cambrian	4,300
				Strawn	Pen	S	Por	2,880	3,870	22			
67	0	1	44	Strawn	Pen	S	Por	4,840	4,857	*y*	*y*	Ellenburger	6,008
68	2	3	40	Bend	Pen	Cgl	Por	6,120	6,130	10	N	Bend	6,131
69	3	4	40	Marble Falls	Pen	L	Por	7,176	7,236	*y*	*y*	Simpson	8,147
70	1	0	40	Simpson	Ord	S	Por	7,170	7,201	*y*	*y*	Ellenburger	7,256
71	0	37	32	Canyon	Pen	LS	Por	1,700	1,765	5	AM	Pre-Cambrian	3,648
72	2	0	45	Bend	Pen	L	Por	6,016	6,050	*y*	*y*	Bend	6,070
73	2	0	41	Simpson	Ord	S	Por	7,200	7,223	*y*	*y*	Simpson	7,223
74	0	809	22–42	Cisco	Pen	S	Por	230*y*	1,900*y*	*y*	A	Pre-Cambrian	3,024
				Canyon	Pen	LS	Por						
				Strawn	Pen	S	Por						
75	11	2	47	Bend	Pen	Cgl	Por	5,690	5,795	10	N	Ellenburger	6,092
				Ellenburger	Ord	DL	Por	5,800	5,875	20			

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Number of Oil and/or Gas Wells				
							During 1942		End of 1942	
			Oil	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]
	Montague County:									
76	Rogers and Rogers	1939	900	1,638,771	434,401	47	2	1	0	46
77	Sanders	1942	160	79,215	79,215	4	4	0	0	4
78	Seitz	1933	300	1,169,582	190,210	52	3	0	0	49
79	Stoneburg	1941	80	15,939	15,273	2	1	0	0	2
80	Thomas	1941	20	2,948	1,782	1	0	0	0	1
81	Turner	1941	40	14,361	9,468	1	0	0	0	1
82	All Other Fields	1940	280	13,436	12,593	7	6	0	0	6
	Total Montague County		7,720	38,600,849	3,059,246	1,227*y*	39	19*y*	*y*	1,095
	Wichita County:									
83	Asylum	1938	80	87,787	20,583	3	0	0	0	3
84	K. M. A.—Ellenburger	1940	5,450	2,807,497	2,182,737	162	47	0	0	162
85	K. M. A.—Strawn	1931	29,500	44,032,381	9,052,528	16*yy*	19	8	5	1,607[3]
86	Oates	1940	140	200,188	103,563	37	1	0	0	37
87	Underwood	1939	60	64,407	13,860	10	0	0	0	9
88	All Other Fields	1900	*y*	324,537,681	4,218,275	*y*	*y*	*y*	*y*	5,518
	Total Wichita County		*y*	371,729,941	15,591,546	*y*	*y*	*y*	*y*	7,336
	Wilbarger County:									
89	Castleberry	1937	200	514,716	113,357	24	1	0	0	24
90	Consolidated (incl. Ellenburger)	1939	600	1,277,237	328,061	52	9	1	0	51
91	Electra-Ellenburger	1941	80	17,965	10,504	2	0	0	0	2
92	Fargo	1940	1,800	1,088,648	726,829	45	1	0	0	45
93	Fluhman	1926	200	[2]	13,949	22	0	0	0	13
94	Harrold	1941	160	112,869	79,898	9	3	0	0	9
95	King	1939	80	72,484	9,457	10	0	3	0	7
96	King-Lawson	1936	20	23,393	2,729	2	0	0	0	2
97	King-Waggoner	1936	120	129,077	12,251	10	0	0	0	10
98	Lawson	1935	80	269,804	21,680	15	0	0	0	15
99	Millham	1925	100	[2]	6,917	14	0	0	0	9
100	Phillips-King	1938	120	121,391	26,519	6	0	0	0	6
101	Potts	1942	100	22,179	22,179	3	3	1	0	2
102	Rock Crossing-Canyon	1937	420	325,621*y*	181,322	31	3	0	0	31
103	Rock Crossing-Ellenburger	1941	240	63,021	53,408	6	3	0	0	6
104	Zenith	1930	80	[2]	5,392	12	0	0	0	8
105	All Other Fields	1915	*y*	[2]	1,960,186	*y*	*y*	*y*	*y*	1,437
	Total Wilbarger County		*y*	79,348,128	3,574,638	*y*	*y*	*y*	*y*	1,677
	Total NORTH TEXAS DISTRICT		*y*	675,024,735	35,781,402	*y*	308	*y*	*y*	16,386

TABLE I.—(*Continued*)

Line Number	Oil-production Methods, End of 1942		Character of Oil	Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells		Gravity A.P.I. at 60°F. Weighted Average					Depth, Avg. Ft.					
	Flowing	Artificial Lift		Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
76	19	27	43	Strawn Bend	Pen Pen	S & L LCgl	Por Por	4,280 5,125	4,680 5,250	y y	A	Ellenburger	6,988
77	3	1	37	Bend	Pen	Cgl	Por	5,962	5,972	y	y	Ellenburger	6,860
78	0	49	37	Canyon U. Strawn L. Strawn	Pen Pen Pen	S S S	Por Por Por	1,610 1,755 2,015	1,615 1,770 2,020	5 10 5	AL	y	2,741
79	1	1	45	Bend	Pen	Cgl	Por	6,233	6,241	8	y	Viola	6,610
80	0	1	y	Strawn	Pen	S	Por	3,023	3,045	y	y	Ellenburger	4,646
81	1	0	41	Bend	Pen	Cgl	Por	6,222	6,234	12	y	Ellenburger	7,501
82	1	5											
	76	1,019											
83	0	3	42	Smithwick	Pen	L	Por	5,076 5,336	5,120 5,362	20	y	Ellenburger	5,418
84	136	26	42	Ellenburger	Ord	DL	Por	4,330	4,440	30	AC	Ellenburger	4,494
85	995[3]	612[3]	40	Strawn	Pen	OLS	Por	3,500	4,000	25	AC	Ellenburger	4,494
86	0	37	y	Cisco	Pen	S	Por	1,313	1,328	12	N	Cisco	1,340
87	0	9	40	Cisco	Pen	S	Por	1,200	1,210	6	y	Cisco	1,482
88	4	5,514											
	1,135	6,201											
89	6	18	36	Cisco Canyon	Pen Pen	S L	Por Por	2,170 3,190	2,650 3,210	9 15	M	y	3,750
90	16	35	40	Canyon Strawn Bend Ellenburger	Pen Pen Pen Ord	S S L DL	Por Por Por Por	1,750 3,750 4,025 4,300	1,770 3,770 4,065 4,380	10 20 20 17	A	Ellenburger	4,381
91	1	1	43	Ellenburger	Ord	DL	Por	3,627	3,635	8	AC	Ellenburger	3,635
92	10	35	42	Cisco Canyon Strawn	Pen Pen Pen	S L S	Por Por Por	3,200 3,970 4,370	3,270 4,020 4,470	25 15 15	A	Ellenburger	6,717
93	0	13	40	Cisco	Pen	S	Por	1,450 1,800 2,040	1,490 1,890 2,060	y y 20	ML	y	2,867
94	2	7	41	Canyon	Pen	S	18	3,160 3,270	3,180 3,350	12 15	A	y	4,412
95	0	7	38	Cisco	Pen	S	Por	1,220	1,960	y	ML	y	2,671
96	0	2	y	y	Pen	S	Por	1,990	2,160	10	ML	Canyon	2,805
97	0	10	40	Cisco	Pen	S	Por	1,535	1,560	10	ML	Cisco	1,784
98	0	15	41	y	Pen	S	Por	1,310 2,296	1,640 2,440	16 10	ML	y	3,174
99	0	9	y	Cisco	Pen	S	Por	1,270	1,300	y	ML	y	2,725
100	1	5	36	Cisco Canyon	Pen Pen	S L	Por Por	y 2,500	1,902 2,900	y y	y	y	3,370
101	0	2	42	Strawn Ellenburger	Pen Ord	S DL	Por Por	4,053 4,506	4,064 4,539	11 11	y	Ellenburger	4,583
102	11	20	y	Canyon	Pen	L	Por	3,015	3,025	10	A	Ellenburger	3,815
103	4	2	39	Ellenburger	Ord	DL	Por	3,770	3,800	10	A	Ellenburger	3,815
104	0	8	y	Cisco	Pen	S	Por	2,190	2,220	15	y	y	2,863
105	2	1,435											
	53	1,624											
	1,611	14,775											

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[3] Includes 100 wells used for gas input; allowable for these wells produced by other wells.

curve indicates that the decline is being retarded to some extent as a result of the pressure-maintenenace program. Production during the year 1942 amounted to approximately 32,000 bbl. of oil per pound drop in bottom-hole pressure. The average producing gas-oil ratio during December 1942 was 1701 cu. ft. per barrel, as compared with a ratio of 1359 cu. ft. per barrel during December 1941.

OUTLOOK FOR 1943

The tendency toward deeper exploration in the district noted during the past three

TABLE 2.—*Summary of Drilling Operations in North Texas*

Discoveries, Extensions, and Important Wildcats Drilled during 1942

	Field	County	Drilled By	Well No. and Farm	Survey
1	Browning	Archer	Perry Browning	Fee No. 1	G. E. C.
2	Cooper	Archer	G. W. Cooper	C. Knight No. 1	S. P. R. R.
3		Archer	Grace and Grace	M. Wear No. 1	Crawford
4		Archer	G. W. Scholl	C. W. Cahoon No. 1	J. Riddle
5		Archer	W. R. Stafford	J. T. Richardson No. 2	W. C. McCune
6		Archer	W. E. Production Co.	A. M. Anderson No. 1	Meade
7		Archer	W. E. Production Co.	J. F. Ebnother No. 1	Harris
8		Archer	Continental Oil Co.	W. P. Ferguson No. 1	S. P. R. R.
9	Rendham	Baylor	Jordan Petroleum Co.	Christie No. 1	F. C. S. L.
10	Costley	Clay	Wilder Drlg. Co.	C. T. Taylor No. 1	Bacon
11	Halsell	Clay	Bridwell Oil Co.	F. Halsell No. 8-A	J. Rogers
12	Halsell	Clay	Bridwell Oil Co.	F. Halsell No. 9-A	A. P. Belcher
13	New York City	Clay	Deep Oil Dev. Co.	K. N. Hapgood No. 1	J. Walker
14	Watson	Clay	Continental et al.	H. Watson No. 1	W. A. Farris
15	Watson	Clay	Whitaker Oil Co.	Gragg No. 1	T. E. & L.
16		Cooke	Stogner, Rector et al.	R. Berry et al No. 1	Hardwick
17		Foard	Sullivan et al.	G. McCoy No. 1	J. M. Seaton
18	Forestburg	Montague	Sinclair-Prairie	I. M. Jones No. 1	Singletary
19	Hildreth	Montague	Continental Oil Co.	J. Hildreth No. 1	E. T. R. R.
20	Mueller	Montague	Continental Oil Co.	P. Mueller No. 1	Hamilton
21	Sanders	Montague	Sinclair-Prairie	J. Sanders No. 1	J. H. Belcher
22		Montague	Continental Oil Co.	J. A. Ketchum No. 1	Hill Co. Sch. Ld.
23		Montague	R. C. Lipscomb	W. F. Harmon No. 1	W. C. Winters
24		Montague	Seitz, Comegys, & Seitz	E. B. King No. 1	E. B. Wooten
25		Montague	Sinclair-Prairie	J. H. Eanes No. 1	G. A. Bench
26		Montague	Continental Oil Co.	J. F. Yowell No. 1	L. C. S. L.
27		Montague	Sinclair-Prairie	M. E. Collier No. 1	J. Collier
28	K. M. A.	Wichita	Grace and Grace	T. P. Dorris No. 1	J. R. Burris
29	Potts	Wilbarger	Consolidated Oil Co.	A. D. Potts No. 1-D	H. & T. C.
30	Potts	Wilbarger	Consolidated Oil Co.	A. D. Potts No. 2-D	H. & T. C.

years should continue, and further development of the older horizons will be seen in spite of drilling curtailment due to the war. The number of wildcat wells successfully completed during the past year, together with firm demand and possible higher prices for crude oil, indicate continuance of the present rates of exploratory work in this area during the coming year.

ACKNOWLEDGMENTS

The writers are indebted to Mr. D. V. Carter for information and assistance in preparing this paper.

TABLE 2.—(*Continued*)

Discoveries, Extensions, and Important Wildcats Drilled during 1942

	Producing Formation	Depth Completed	Total Depth	Surface Formation	Deepest Horizon Tested	Initial Production per Day	Choke or Bean, Fractions of an Inch	Remarks
						Oil, U. S. Bbl.		
1	Ellenburger	5,321–5,330	5,330	Permian	Ellenburger	73, 3 hr.	32/64 choke	One well only
2	Detrital	4,888–4,903	5,028	Permian	Ellenburger	131	¼ choke	One well only
3	Cisco	1,273–1,282	1,282	Permian	Cisco	10	Pumping	One prod., extension to old field
4	Cisco	945– 960	1,103	Permian	Cisco	10	Pumping	One well only
5	Cisco	1,224–1,243	1,243	Permian	Cisco	169	Pumping	Eight prod., extension to old field
6	Cisco	1,452–1,462	1,462	Permian	Cisco	67	Pumping	One well only
7	Cisco	1,277–1,280	1,280	Permian	Cisco	86	Pumping	Four prod., extension to old field
8	Ellenburger	5,089–5,118	5,270	Permian	Ellenburger			Dry and abandoned
9	Canyon	3,017–3,023	3,025	Permian	Canyon	90	Pumping	Extension
10	Cisco	1,073–1,078	1,078	Permian	Cisco	61	Pumping	Extension
11	U. Strawn	3,656–3,663	3,916	Perm-Penn.	Strawn	17	Pumping	New pay
12	Bend	5,432–5,444	5,444	Perm-Penn.	Bend	2	Pumping	New pay
13	Strawn	4,921–4,937	6,544	Pennsylvanian	Simpson	125	Pumping	New pay
14	Bend	5,452–5,483	5,505	Perm-Penn.	Bend	206, 6 hr.	½ choke	Ten prod., no failures
15	Strawn	3,655–3,676	3,680	Perm-Penn.	Strawn	115	Pumping	Additional pay
16	Ellenburger	6,001–6,003	6,003	Comanchean	Ellenburger			Dry and abandoned
17	Bend	5,592–5,600	6,019	Permian	Ellenburger			Dry and abandoned
18	Marble Falls	7,176–7,320	8,696	Comanchean	Ellenburger	888, 9 hr.	2½ choke	Seven prod., no failures
19	Simpson	7,170–7,201	7,256	Pennsylvanian	Ellenburger	329	15/32 choke	One prod., no failures
20	Simpson	7,218–7,223	7,223	Comanchean	Simpson	369	¾ choke	Two prod., no failures
21	Bend	5,961–5,972	5,972	Pennsylvanian	Bend	375, 3 hr.	2 choke	Four prod., no failures
22	Strawn	3,330–3,336	7,506	Comanchean	Ellenburger	36	Pumping	One well only
23	Strawn	3,860–3,880	4,982	Pennsylvanian	Ellenburger	150	Pumping	One well only
24	Canyon	1,630–1,637	2,517	Comanchean	Strawn	20	Pumping	One well only
25	Bend	5,828–5,922	7,070	Pennsylvanian	Ellenburger	70	1 choke	One well only
26	Ellenburger	7,156–7,224	7,224	Pennsylvanian	Ellenburger			Dry and abandoned
27	Ellenburger	7,715–7,739	8,000	Pennsylvanian	Ellenburger			Dry and abandoned
28	Strawn	4,102–4,140	4,178	Permian	Strawn	57	Pumping	Extension
29	Ellenburger	4,506–4,539	4,539	Permian	Ellenburger	156, 3 hr	¾ choke	One prod., two failures in Ellenburger, discovery well now plugged
30	Strawn	4,053–4,064	4,589	Permian	Ellenburger	70	Pumping	Additional pay, one producing

Number of oil wells completed in 1942	308
Number of gas wells completed in 1942	0
Number of dry holes completed in 1942	175

Oil and Gas Developments in the Texas Panhandle in 1942*

In the Texas Panhandle 277 oil wells and 60 gas wells were completed during 1942, as compared with 647 oil and 52 gas wells completed in 1941. Fourteen dry holes were drilled in the Texas Panhandle in 1942, of which five were wildcats, resulting in four failures and one gas-field discovery in Sherman County; the latter being Hazy-Herrington-Marsh No. 1 Bivins completed for 5,600,000 cu. ft. of gas from 2989 to 3226 feet.

During the year 1942 the Texas Panhandle produced, by counties, the following quantities of oil:

County	Total Oil Production, Bbl.	
	To End of 1942	During 1942
Carson	43,041,190	4,112,016
Gray	198,354,766	13,600,622
Hutchinson	166,734,281	11,392,135
Moore	5,300,972	162,688
Wheeler	21,951,682	1,491,928
Total	435,416,713[a]	30,759,389

[a] Includes 33,822 bbl. produced in Potter County.

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* Abbreviated summary from the Texas Railroad Commission data in the absence of the regular author. Manuscript received at the office of the Institute April 20, 1943.

Oil and Gas Development in South Texas during 1942

By James J. Halbouty,* Junior Member A.I.M.E.

The restraining effects of war conditions on oil-field development are well illustrated by statistics on South Texas† fields for the year 1942. Statistics also show a decline in wildcatting, but this decrease is much smaller than that shown by field activity. In comparison with results in 1941, there was a reduction of about 44 per cent in the *total* number of wells drilled in the area (802 in 1942 against 1452 in 1941). This 44 per cent drop represents declines of 50.4 per cent in field wells and of 17.4 per cent in rank wildcats. Field wells (exclusive of 18 wildcats that discovered fields) totaled 598; also, 204 rank wildcats were drilled (see Tables 3 and 4). The corresponding figures for 1941 are 1205 field and extension wells and 247 rank wildcats. In this connection, it should be noted that whereas in 1941 the rank wildcats made up only 17 per cent of all wells drilled in the area, their percentage of the 1942 total was 25.4 per cent. In spite of the decrease of 43 in the number of rank wildcats‡ drilled, there were 18 new productive areas discovered, one more than the 17 new fields found in 1941. Thus the field-discovery rate for 1942, one new field for every 11.3 wildcats drilled, compares favorably with the 1 to 14.5 rate of 1941.

Thirteen new producing levels were opened in fields; this includes the finding of 44° gravity crude on the west flank of the Sejita field in a 5700-ft. sand, which produces distillate higher on the structure. Interesting, and showing the general scarcity of sand discoveries, is the fact that of the 13 new sands discovered, 7 were found in Jim Wells County. The year's sand-discovery rate of one new level for every 46 field wells compares very unfavorably with the 1 to 19.7 rate of 1941, during which 61 new producing horizons were found.

Development of *new* fields was on a small scale. In several instances activity in these areas was not carried beyond the drilling of the discovery well. The field discoveries of 1942, together with the type of production obtained from the discovery wells and the total number of wells (productive and dry) drilled in them, are given below:

Field[a]	County	Discovery Well Produced	Number Wells[b]
1. Cadena	Duval	Oil	2
2. Garza	Duval	Oil	1
3. Dinn	Duval	Gas	1
4. Keller	Duval	Gas	1
5. East	Jim Hogg	Oil	1
6. Green Branch	McMullen	Gas	3
7. Frost	Starr	Oil	1
8. Garcia	Starr	Oil	6
9. Ulrich	Starr	Oil	4
10. Lykes	Webb	Oil	2
11. McLean	Webb	Oil	9
12. Alamo	Hidalgo	Distillate and gas	2
13. Penitas	Hidalgo	Distillate and gas	2
14. Koopman	Jim Wells	Oil	3
15. South Premont	Jim Wells	Distillate and gas	1
16. Quinto Creek	Jim Wells	Gas	4
17. Roth	Jim Wells	Gas	1
18. South Sinton	San Patricio	Distillate and gas	1

[a] See Table 2 for data on discovery wells and Table 1 for information on these fields.

[b] See Table 4.

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† South Texas, in this paper, includes two areas: the Laredo district (Duval, Jim Hogg, LaSalle, McMullen, Starr, Webb, Zapata Counties) and the South Corpus Christi district (Brooks, Cameron, Hidalgo, Jim Wells, Kenedy, Kleburg, Nueces, San Patricio, Willacy Counties).

‡ The term *rank* wildcat is considered to exclude those semiwildcats that, though relatively distant from fields, brought in production classification as *extensions* to those fields.

TABLE 1.—*Oil and Gas Production in South Texas*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude-oil Production, Bbl.[4]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
1	Adami, *Webb*	1939	400	10	481,391	96,116
2	Agua Dulce,[1] *Nueces and Jim Wells*	1928	4,000	12,000	1,566,994	732,414
3	Agua Prieta, *Duval*	1941	20	0	7,047	3,152
4	Alamo, *Hidalgo*	1942	0	80	Gas	Gas
5	Albercas, *Webb*	1927	250	200	2,542,084	10,805
6	Alfred,[2] *Jim Wells*	1938	500	40	472,084	105,853
7	Alice, *Jim Wells*	1938	1,280	400	2,763,437	234,766
8	East Alice (Tom Graham), *Jim Wells*	1938	750	360	1,344,238	183,692
9	Alta Mesa, *Brooks*	1926	1,250	350	1,194,039	167,269
10	Alta Verde,[3] *Brooks*	1936	100	60	8,643	0
11	Alworth,[10] *Jim Hogg*	1926	80	570	27,793	0
12	Andrews,[11] *Zapata*	1924	0	2,000	Gas	
13	Angelita,[12] *San Patricio*	1934	60	0	36,798	0
14	Aransas (gas),[11] *San Patricio*	1931	0	760	Gas	Gas
15	Aransas Pass (McCampbell), *San Patricio and Aransas*	1936	3,200	450	11,314,531	627,222
16	Armagosa, *Jim Wells*	1931	0	400	Gas	Gas
17	Arroyo Grande,[11] *Starr*	1924	0	320	Gas	
18	Aviator, *Webb*	1922	955	320	6.175,498	88,933
19	Baffins Bay,[12] *Kleburg*	1940	20	0		
20	Baldwin (South Saxet), *Nueces*	1935	270	40	858,400	42,984

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Includes North, East and South Agua Dulce.

[2] Includes Alfred Prospect (Gas) and West Alfred.

[3] Temporarily abandoned.

[4] Crude, distillate and gas production figures obtained from Texas Railroad Commission. Crude production to end 1942 revised to conform with R.R. Commissions total.

[10] Depleted.

[11] Abandoned?

[12] Abandoned.

TABLE I.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells							Oil-production Methods, Crude, End of 1942		Number of Crude-oil Operators in Field, End 1942
			Completed to End of 1942	During 1942	Capable of Producing Gas[6]	End of 1942			Number Wells Producing Crude Oil	Number of Wells		
				Completed		Producing Gas	Gas Wells Capable of Producing Distillate	Producing Distillate		Flowing	Artificial Lift	
1	0	0	72	0	0	0	0	0	64	0	64	11
2	75,782 2,084,792[5]	89,538,497	252	45[7]	124	58	122	58	92	86	6	24
3	0	0	1	0	0	0	0	0	1	1	0	1
4	1,498	23,700	2	2	2	0	2	0	0	0	0	0
5	0	0	100	0	8	0	0	0	8	0	8	2
6	67	67,537	24	0	1	1	1	1	22	17	5	6
7	2,292 140,849[5]	95,746	73y	1[8]	8	2	7	2	52	40	12	10
8	118,157[5]	23,514,249	53y	0	18	8	16	8	35	35	0	10
9	0	17,970	44	0	3	1	0	0	33	2	31	1
10	0	0	6	0	0	0	0	0	0	0	0	0
11	0	0	16	0	0	0	0	0	0	0	0	0
12			12	0	y							
13	0	0	3	0	1	0	1	0	0	0	0	0
14	0	0	19	0	y	0	0	0	0	0	0	0
15	40,743	3,911,419	362	0	29	12	26	10	202	83	119	28
16	0	877,886	7	1	7	5	0	0	0	0	0	0
17	0	0	8	0	y	0	0	0	0	0	0	0
18	0	0	216	0	0	0	0	0	73	0	73	3
19	0	0	1	0	0	0	0	0	0	0	0	0
20	0	137,439	9	0	1	1	0	0	8	0	8	3

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[5] Condensate, Gasoline, Kerosene, etc., obtained from Gas during Recycling Operations.
[6] Wells producing Gas along with Crude Oil are not included.
[7] Includes one gas input well.
[8] Includes one deepened well.

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[9]								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
1		20.8	Mirando	Eoc	S	Por	975	1,000	7	ML	Yegua	1,517
2	PM	Gas	Catahoula	Olig	S	Avg. = 30	1,998	2,400	10	AF	Yegua	13,728
		55	Frio	Olig	S		4,650	4,675	9			
		35.4–59	Frio	Olig	S		4,800	4,900	15			
		56	Frio	Olig	S		5,081	5,088	7			
		37.5–59.7	Frio	Olig	S		5,295	5,309	10			
		42.6–56	Frio	Olig	S		5,560	5,736	15			
		42.8–60	Frio	Olig	S		5,830	5,850	20			
		55–60	Frio	Olig	S		6,396	6,740	20			
		39.8–50.9	Frio	Olig	S		6,795	6,958	15			
		38.6–56	Frio	Olig	S		6,978	7,056	18			
		40.2	Frio	Olig	S		7,068	7,160	20			
		56	Frio	Olig	S		7,200	7,261	20			
3		46	Pettus	Eoc	S	Por	4,708	4,720	12	NFy	Yegua	5,025
4		58	Frio	Olig	S	Por	5,505	5,998	25	y	Frio	6,567
5		21	McElroy	Eoc	S	Por	2,125	2,175	17	MFL	Yegua	3,710
6		44.7	Frio	Olig	S	30–35	3,225	3,234	11	NFL	Jackson	6,535
		47.4	Frio	Olig	S	Por	4,194	4,206	12			
		48.5	Frio	Olig	S	Por	4,304	4,313	9			
		41.5	Vicksburg	Olig	S	30-35	4,660	4,695	15			
7	PM	42	Frio	Olig	S	28.7	3,480	3,600	16	ANL	Yegua	7,767
		38.9	Frio	Olig	S	Por	4,788	4,801	11			
		40	Frio	Olig	S	Por	5,030	5,161	12			
		44.8	Frio	Olig	S	Por	5,211	5,223	12			
		43.6–60	Vicksburg	Olig	S	Por	5,350	5,375	20			
		43.6	Vicksburg	Olig	S	Por	5,450	5,576	20			
		49.5	Yegua	Eoc	S	Por	y	7,767	y			
8	PM	38	Frio	Olig	S	Por	3,480	3,496	15	ANL	Vicksburg	5,760
		54	Frio	Olig	S	Por	4,675	4,700	10			
		56	Frio	Olig	S	Por	5,125	5,175	12			
		42.6–56	Frio-Vicksburg	Olig	S	Por	5,300	5,400	18			
9		Gas	Oakville	Mio	S	Por	1,100	1,140	20	Ds	Jackson	8,022
		24.5	Catahoula	Olig	S	Por	2,434	2,600	12			
		24.5	Catahoula	Olig	S	Por	2,986	3,025	10			
		25.5	Catahoula	Olig	S	Por	3,475	3,585	20			
10		21.5	Caprock	Mio	S	Por	916	926	10	Ds	Jackson y	5,096
11		21	McElroy	Eoc	S	Por	1,020	1,030	6	ML	Yegua	2,199
12		Gas	McElroy	Eoc	S	Por	1,500	1,515	5	MF	Yegua	2,312
13		38	Frio	Olig	S	Por	5,370	5,382	10	NFL	Frio	7,131
		36	Frio	Olig	S	Por	6,225	6,235	10			
14		Gas	Catahoula	Olig	S	Por	3,653	3,663	10	D	Frio	6,026
15		49.3	Marginulina	Olig	S	25–34	6,539	6,554	15	AF	Frio	9,492
		42.4	Frio	Olig	S		6,780	6,888	15			
		38.8	Frio	Olig	S		7,080	7,180	18			
		41.2	Frio	Olig	S		7,200	7,270	15			
		58	Frio	Olig	S		7,345	7,419	15			
		56	Frio	Olig	S		7,454	7,461	7			
16		Gas	Discorbis-Het.	Olig	S	Por	2,170	2,680	10	D	Yegua	6,315
17		Gas	Jackson	Eoc	S	Por	435	450	8	MF	Mt. Selman	4,015
		Gas	Cook Mt.	Eoc	S	Por	2,120	2,161	12			
		Gas	Mt. Selman	Eoc	S	Por	3,208	3,214	6			
18		21	Mirando	Eoc	S	Por	1,525	1,660	11	MfL	Cook Mt.	3,975
19		39.3	Frio	Olig	S	Por	7,394	7,450	10	AF	Frio	9,428
20		Gas	Oakville	Mio	S	Por	3,230	3,250	12	AF	Frio	6,610
		25.9	Catahoula	Olig	S	Por	3,874	3,880	6			
		23.3	Catahoula	Olig	S	Por	4,050	4,074	12			

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[9] For data on Stratigraphy, Surface Formations and Elevations, see A.I.M.E. TRANSACTIONS, volume 146, 1942, page 475.

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[a]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
21	Bandera,[11] *Jim Wells*	1938	0	80	Gas	
22	Banquette,[11] *Nueces*	1941	0	80	0	0
23	Barbacoas, *Starr*	1933	80	580	33,794	482
24	Benavides (North Sweden), *Duval*	1937	3,900	600	11,465,924	746,130
25	East Benavides, *Duval*	1941	40	0	13,125	5,535
26	Ben Bolt, *Jim Wells*	1939	2,400	320	2,040,195	398,301
27	Bird Island, *Kleburg*	1938	40	80	38,474	6,080
28	Blanchard (Muralla), *Duval*	1939	60	40	42,485	4,772
29	Blas Uribe,[11] *Zapata*	1934	0	80	Gas	
30	Blucher,[11] *Jim Wells*	1939	0	40	Gas	
31	Boyle, *Starr*	1940	200	20	170,482	72,582
32	Bridwell, *Duval*	1940	200	20	103,949	27,465
33	Cadena, *Duval*	1942	40	0	4,268	4,268
34	Calliham (including South Calliham), *McMullen*	1918	500	730	1,041,464	45,750
35	Camada, *Jim Wells*	1939	40	0	4,099	426
36	Campana, *McMullen*	1938	10	0	831	0
37	South Campana, *McMullen*	1941	150	20	60,689	53,328
38	Captain Lucey (West Bentonville), *Jim Wells*	1932	120	520	519,078	28,858
39	Carolina-Texas, *Webb*	1921	110	1,460	256,670	0
40	Casa Blanca, *Duval*	1938	550	80	572,400	113,461
41	North Casa Blanca, *Duval*	1939	100	0	116,716	25,440
42	West Casa Blanca, *Duval*	1941	160	40	81,769	38,145
43	Cedro Hill, *Duval*	1938	770	40	710,028	196,997
44	Chaparosa,[11] *Jim Hogg*	1941	20	40	*y*	*y*
45	Chapman Ranch, *Nueces*	1937	100	80	67,076	15,311
46	Charamousca (including South Charamousca), *Duval*	1935	410	0	766,106	122,249
47	Charco Redondo, *Zapata*	1913	570	60	164,536	742
48	Chiltipin, *Duval*	1939	60	20	42,223	11,923

TABLE I.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells							Oil-production Methods, Crude, End of 1942		Number of Crude-oil Operators in Field, End 1942
			Completed to End of 1942	During 1942	Capable of Producing Gas[6]	End of 1942			Number Wells Producing Crude Oil	Number of Wells		
				Completed		Producing Gas	Gas Wells Capable of Producing Distillate	Producing Distillate		Flowing	Artificial Lift	
21	0	0	2	0	2	0	2	0	0	0	0	0
22	0	0	2	0	2	0	2	0	0	0	0	0
23	0	0	14	0	y	0	y	0	1	0	1	1
24	6,332	429,539	278	0	10	5	6	4	221	96	125	19
25	0	0	2	1	0	0	0	0	1	1	0	1
26	685	52,024	81	11[14]	8	3	3	2	67	65	2	13
27	0	2,083	3	0	2	0	2	0	1	1	0	1
28	1,936	128,518	4	0	1	1	1	1	2	2	0	1
29	0	0	3	0	1	0	0	0	0	0	0	0
30	0	0	1	0	1	0	1	0	0	0	0	0
31	0	2,578	13	1	1	1	0	0	12	11	1	5
32	0	0	11	0	0	0	0	0	10	10	0	3
33	0	0	2	2	0	0	0	0	2	1	1	1
34	0	0	142	0	0	0	0	0	59	0	59	11
35	0	0	2	0	0	0	0	0	1	0	1	
36	0	0	1	0	0	0	0	0	0	0	0	
37	0	466	14	7	3	0	0	0	13	13	0	4
38	731	1,110,057	23	0	14	9	4	2	6	2	4	3
39	699	195,707	66	0	7	4	2	0	0	0	0	0
40	0	6,379	58	8	3	2	0	0	49	0	49	5
41	0	0	9	0	0	0	0	0	9	0	9	2
42	0	214	20	0	4	1	0	0	16	0	16	2
43	0	72,674	81	0	3	1	2	0	77	14	63	3
44	y	y	4	2	y	0	y	0	0	0	0	0
45	1,468	174,525	5	0	3	0	3	0	2	0	2	1
46	0	0	41	0	0	0	0	0	34	1	33	3
47	0	0	340	0	0	0	0	0	28	0	28	1
48	0	0	6	0	1y	0	0	0	5	5	0	3

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[14] Includes two deepened wells.

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[9]								Deepest Zone Tested to End of 1942	
							Depth, Avg. Ft.					
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
21		Gas—56	Jackson	Eoc	S	Por	6,408	6,416	8	AF	Yegua	8,302
22		Gas—58.6	Frio	Olig	S	Por	6,705	6,714	9	A	Frio	7,538
		Gas—56	Frio	Olig	S	Por	6,978	6,983	5			
23		Gas	Catahoula	Olig	S	Por	200	715	10	AF	Yegua	6,567
		Gas—24.9	Frio	Olig	S	Por	2,450	2,950	15			
		58	Cockfield	Eoc	S	Por	5,376	5,398	22			
24	PM	41.8	Cole	Eoc	S	Avg. = 27	3,840	3,975	22	[13] AFL	Yegua	6,510
		42.9	Chernosky	Eoc	S		4,357	4,552	15			
		47.2	Upper Govt. Wells	Eoc	S		4,730	4,755	20			
		43.3	Lower Govt. Wells	Eoc	S		4,755	4,830	25			
		39.6–60	Pettus	Eoc	S		5,310	5,382	22			
		45	Yegua	Eoc	S		5,486	5,518	17			
		56	Yegua	Eoc	S		5,584	5,594	10			
		65	Yegua	Eoc	S		5,715	5,749	20			
25		43	Govt. Wells	Eoc	S	Por	4,915	4,940	20	AF	Yegua	6,510
26		34	Frio	Olig	S	Por	4,503	4,550	10	ANL	Jackson	6,140
		30-42.8	Frio	Olig	S	Por	4,802	4,875	12			
		42.5	Frio	Olig	S	Por	4,900	4,920	15			
		42-55	Frio	Olig	S	32.7	5,120	5,344	15			
		42.5	Vicksburg	Olig	S	Por	5,370	5,671	15			
27		44	Frio	Olig	S	Por	7,200	7,310	80y	AF	Frio	9,636
28		43	Pettus	Eoc	S	Por	4,683	4,822	8	MF	Yegua	5,807
29		Gas	Yegua	Eoc	S	Por	1,825	1,840	15	ML	Cook Mt.	3,000
30		Gas—54	Vicksburg	Olig	S	Por	7,500	7,560	20	A	Vicksburg	8,004
31		Gas-Dist.	Frio	Olig	S	Por	2,850	2,855	5	AF	Jackson	4,520
		47.7	Frio	Olig	S	Por	3,149	3,186	15			
		44	Frio	Olig	S	Por	3,475	3,525	12			
32		43.5	Pettus	Eoc	S	Por	4,292	4,335	10	MF	Yegua	4,657
33		43	Pettus	Eoc	S	Por	5,269	5,275	6	AF	Yegua	5,800
34		20	Mirando[15]	Eoc	S	Por	848	876	15	MFL	Carrizo	5,301
		20.6	Govt. Wells-Pettus[15]	Eoc	S	Por	1,030	1,060	10			
		Gas	Loma Novia	Eoc	S	Por	1,221	1,250	10			
35		46	Chernosky	Eoc	S	Por	5,627	5,637	10	NL	Yegua	7,041
36		24	Govt. Wells	Eoc	S	Por	2,492	2,517	20	MF	Pettus	3,102
37		Gas	Cole	Eoc	S	Por	1,864	1,867[16]	3y	MF	Cook Mt.	4,486
		Gas	Govt. Wells	Eoc	S	Por	2,554	2,568	10			
		22.8	Pettus	Eoc	S	Por	3,012	3,045	12			
38		Gas	Frio	Olig	S	Por	3,893	4,000	6	AF	Jackson	6,500
		36.4	Frio	Olig	S	Por	5,350	5,370	20			
		41.4	Vicksburg	Olig	S	Por	5,679	5,685	7			
39		Gas	Cole	Eoc	S	Por	1,270	1,305	10	DFL	Wilcox	9,228
		Gas	McElroy	Eoc	S	Por	1,800	2,200	10			
		34	Cockfield	Eoc	S	Por	2,597	2,615	10			
		27.6	Yegua	Eoc	S	Por	2,947	3,198	18			
		42-60	Queen City	Eoc	S	Por	4,996	5,056	60y			
40		21	Cole	Eoc	S	Por	1,180	1,190	10	ML	Yegua	2,133
41		21	Cole	Eoc	S	Por	1,030	1,059	9	ML	Jackson	1,788
42		21	Cole	Eoc	S	Por	994	1,045	10	ML	Yegua	2,212
43		20	Cole	Eoc	S	Por	1,436	1,480	10	MFL	Yegua	2,646
44		Gas—47.6	Upper Govt. Wells	Eoc	S	Por	2,781	2,792	10	ML	Pettus	3,512
			Lower Govt. Wells	Eoc	S	Por	2,855	2,868	10			
45		27.9	Catahoula	Olig	S	Por	4,244	4,279	10	NL	Frio	7,750
		40.8	Catahoula	Olig	S	Por	5,046	5,058	12			
		41.8	Frio	Olig	S	Por	6,464	6,484	20			
46		20	Cole	Eoc	S	Por	1,094	1,101	7	MFL	Cook Mt.	3,892
		19.8	McElroy	Eoc	S	Por	1,525	1,581	10			
47		17	Jackson	Eoc	S	Por	150	200	8	ML	Mt. Selman	3,511
		Gas	Jackson	Eoc	S	Por	989	995	5			
48		49.6	Pettus	Eoc	S	Por	4,760	4,795	10	NF	Yegua	5,410

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[13] Also lensed sands are found at 3495 to 3510 ft. in two wells (40.4 gravity oil) and at 5067 to 5123 ft. (44.2 gravity oil).

[15] In Calliham.

[16] Perforations.

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[a]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
49	Clara Driscoll (including South Clara Driscoll and Gandy),[17] *Nueces*	1935	2,600	460	4,845,463	742,424
50	Clark-Muil,[3] *Jim Wells*	1939	80	100	44,015	0
51	Clopton-Green,[12] *Starr*	1937	0	10	Gas	0
	Cole Group, *Duval and Webb*					
52	Shallow (including East Cole)	1924	120	7,000	11,782	7,857
53	O'Hern	1927	2,300	2,200	10,529,371	770,750
54	Bruni (including East Bruni)	1934	880	160	6,981,331	34,235
55	West Cole, *Webb*	1927	500	1,000	706,133	158,840
56	Colmena, *Duval*	1934	240	400	532,768	58,010
57	Colorado, *Jim Hogg*	1936	2,300	40	2,329,376	397,950
58	Comitas (Haynes), *Zapata*	1934	750	40	1,658,897	124,806
59	Conoco Driscoll, *Duval*	1924	1,600	980	4,699,307	920,481
60	Coquat-Lopez,[3,18] *Duval*	1941	10	0	*y*	*y*
61	Corpus Christi (Saxet Heights), *Nueces*	1935	1,500	200	6,757,096	104,050
62	Crowther,[10] *McMullen*	1915	80	0	25,000	0
63	Cuellar, *Zapata*	1927	340	220	2,635,164	15,416
64	Dinn, *Duval*	1942	0	20	Gas	Gas
65	Eagle Hill, *Duval*	1933	550	200	1,679,853	220,885
66	East, *Jim Hogg*	1942	20	0	600	600
67	Edinburg,[12] *Hidalgo*	1935	20	0	500	0
68	El Mesquite,[12] *Duval*	1935	10	0	976	0
69	El Tanque (South Ricaby), *Starr*	1937	200	20	442,412	23,553
70	Escobas-Jennings, *Zapata*	1914	3,700	2,000	10,315,211	444,469
71	Ezzell, *McMullen and Live Oak*	1937	1,450	100	2,789,706	252,462
72	Fitzsimmons, *Duval*	1938	790	10	2,570,318	180,752
73	East Fitzsimmons,[12] *Duval*	1940	10	0	583	0
74	Flour Bluff, *Nueces*	1936	2,280	320	4,220,672	322,549
75	East Flour Bluff, *Nueces*	1940	840	80	345,511	90,597
76	Frost, *Starr*	1942	20	0	2,666	2,666
77	Gallagher, *Jim Wells*	1940	60	0	76,522	18,766
78	Garcia, *Starr*	1942	160	0	18,444	18,444
79	Garza, *Duval* (see Kreis)	1942	20	0	Included in Kreis	
80	Glen, *Webb and Zapata*	1940	710	60	850,731	351,590

[17] Sands in Gandy at 5440 and 5850 ft.

[18] Considered to be part of Cole (shallow) by Railroad Commission.

TABLE 1.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells							Oil-production Methods, Crude, End of 1942		Number of Crude-oil Operators in Field, End 1942
			Completed to End of 1942	During 1942	Capable of Producing Gas[6]	End of 1942			Number Wells Producing Crude Oil	Number of Wells		
				Completed		Producing Gas	Gas Wells Capable of Producing Distillate	Producing Distillate		Flowing	Artificial Lift	
49	5,150	2,781,535	179	3	20	12	10	5	135	78	57	22
50	0	0	8	0	2	0	2	0	0	0	0	0
51	Gas	0	1	0	1	0	0	0	0	0	0	0
52	0	1,376,798	115	3	61	1[22]	0	0	4	0	4	1
53	694	374,870[19]	274	0	16	7	1	0	180	0	180	8
54	0	0[20]	62	0	y	0	y	0	26	1	25	5
55	0	889,043[21]	126	0	20	11	0	0	66	0	66	5
56	0	466,539	36	0	6	4	0	0	19	0	19	5
57	0	237	231	39	1	0	0	0	225	199	26	7
58	0	0	196	0	0	0	0	0	128	0	128	8
59	0	44,493	107	13	6	1	1	0	62	59	3	1
60	0	0	1	0	0	0	0	0	0	0	0	0
61	1,427	358,646	252	0	10	0	7	0	11	1	10	6
62	0	0	23	0	0	0	0	0	0	0	0	0
63	0	358,033	86	0	3	2	0	0	24	0	24	1
64	0	34,361	1	1	1	1	0	0	0	0	0	0
65	0	7,359	61	0	4	3	0	0	51	0	51	5
66	0	0	1	1	0	0	0	0	1	1	0	1
67	0	0	1	0	0	0	0	0	0	0	0	0
68	0	0	1	0	0	0	0	0	0	0	0	0
69	0	0	22	0	0	0	0	0	15	1	14	4
70	0	145,378[23]	539	1	5[23]	2	0	0	332	0	332	9[24]
71	0	71,561	151	0	3	1	0	0	127	0	127	7
72	0	6,988	79	0	1	1	0	0	78	59	19	14
73	0	0	1	0	0	0	0	0	0	0	0	0
74	14,016	1,074,643	117	1	11	5	5	3	90	68	22	5
75	5,385	21,381	23	2	1	1	1	0	20	20	0	1
76	0	0	1	1	0	0	0	0	1	1	0	1
77	0	0	3	0	0	0	0	0	3	3	0	1
78	0	0	4	4	0	0	0	0	4	4	0	1
79	0	0	1	1	0	0	0	0	1	0	1	1
80	0	0	75	2	3	0	1	0	71	23	48	5

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[19] Includes Cole Bruni (Kalmor Cuellar Area, Kohler deep and shallow levels, and 2450-ft., 2500-ft., and 2800-ft. levels).

[20] Refers to sands below 3250 ft.

[21] 2300-ft. zone, Benavides area, Webb County.

[22] 50 gas wells produced in September. Since shut in.

[23] In Jennings.

[24] One in Jennings.

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[a]								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
49		Gas	Catahoula	Olig	S	Por	3,250	3,300	15	AF	Vicksburg	8,194
		Gas—23.5	Heterostegina	Olig	S	Por	3,787	3,980	12			
		31.5	Frio	Olig	S	Por	4,642	4,748	10			
		Gas—37.3	Frio	Olig	S	Por	4,980	5,133	15			
		34.2–38 6	Frio	Olig	S	Por	5,255	5,477	15			
		38.6–58	Frio	Olig	S	Por	5,502	5,890	15			
		38.5	Frio	Olig	S	Por	6,487	6,660	10			
50		60	Frio	Olig	S	Por	4,795	4,835	20	N	Vicksburg	5,850
		40.2	Frio	Olig	S	Por	5,326	5,330	4			
		58	Vicksburg	Olig	S	Por	5,557	5,572	12			
51		Gas	Cole	Eoc	S	Por	1,604	1,614	10	ML	Cook Mt.	4,620
52		Gas	Frio	Olig	S	Por	500	515	10	AfL	Reklaw	6,394
		Gas—20	Cole	Eoc	S	Por	1,650	1,820	10			
53		Gas—29.4	McElroy	Eoc	S	Por	2,300	2,450	10	AFL	Reklaw	6,394
		Gas	O'Hern-Cockfield	Eoc	S	Por	2,750	2,945	15			
54		39.9	Yegua	Eoc	S	Por	3,250	3,280	10	AF	Wilcox	10,295
		38.5–42.4	Yegua	Eoc	S	Por	3,400	3,450	14			
		44	Cook Mt.	Eoc	S	Por	3,938	3,973	15			
		46	Queen City	Eoc	S	Por	5,620	5,675	15			
55		Gas—21.5	McElroy	Eoc	S	Por	2,300	2,350	11	ML	Queen City	5,525
		Gas	Cockfield	Eoc	S	Por	2,900	2,925	10			
56		21	Cole	Eoc	S	Por	1,486	1,553	10	ML	Yegua	3,396
57		47.2	Cockfield	Eoc	S	Por	2,820	3,175	10	ML	Cook Mt.	4,510
58		20.6	McElroy	Eoc	S	Por	800	1,000	10	ML	Cook Mt.	3,502
59		22.5	Frio	Eoc	S	Por	2,448	2,658	20	NL	Cook Mt.	5,390
		23.4	Cole	Eoc	S	Por	2,884	2,995	10			
		36.4	Govt. Wells-Mirando	Eoc	S	Por	3,250	3,561	15			
60		20 6	Cole	Eoc	S	Por	1,693	1,705	12	AL	Cole	1,705
61		25	Catahoula	Olig	S	Por	3,974	4,100	8	A	Frio	7,531
		36.5	Heterostegina	Olig	S	Por	5,157	5,167	10			
62		18	Diboll	Eoc	S	Por	500	520	10	ML	Cook Mt.	2,000
63		Gas	McElroy	Eoc	S	Por	1,100	1,116	16	ML	Mt. Selman	4,532
		20.9	McElroy	Eoc	S	Por	1,325	1,350	10			
64		Gas	Upper Jackson	Eoc	S	Por	2,481	2,491	10	ML*y*	Jackson	3,006
65		19	Cole	Eoc	S	Por	1,490	1,540	10	MFL	Yegua	2,752
		23	Govt. Wells	Eoc	S	Por	2,120	2,150	11			
66		47.5–51	Cockfield	Eoc	S	Por	4,735	4,741[16]	4	NF	Yegua	5,303
67		*y*	Frio	Olig	S	Por	6,685	6,770	20	D	Frio	7,508
68		43	Cockfield	Eoc	S	Por	2,850	2,862	12	ML	Yegua	3,502
69		Gas	Catahoula	Olig	S	Por	425	429	4	NL	Jackson	2,700
		31	Frio	Olig	S	Por	1,702	1,775	14			
		30	Frio	Olig	S	Por	1,866	1,879	6			
70		20.9	Jackson	Eoc	S	Por	900	1,050	10	AFL	Mt. Selman	4,645
		20.9	Jackson	Eoc	S	Por	1,137	1,350	15			
		20.9	Jackson *y*-Yegua	Eoc	S	Por	1,450	1,900	10			
71		20	Loma Novia	Eoc	S	Por	1,490	1,550	11	ML	Cook Mt.	3,108
72		46	McElroy	Eoc	S	Por	3,592	3,623	15	MF	Yegua	5,285
		47	Pettus	Eoc	S	Por	4,260	4,303	25			
73		43.7	Yegua	Eoc	S	Por	4,900	4,916	10	MF	Yegua	5,087
74		43	Marginulina	Olig	S	Por	6,590	6,696	20	AF	Frio	7,504
75		41.6	Marginulina	Olig	S	Por	6,753	6,800	20	AF	Frio	8,694
76		45	Frio	Olig	S	Por	4,184	4,191[16]	7	ML	Jackson *y*	5,435
77		39.4	Frio	Olig	S	Por	5,189	5,226	18	NFL	Jackson	6,260
		39.4	Vicksburg	Olig	S	Por	5,744	5,761	15			
78		42	Frio	Olig	S	Por	3,740	3,755	15	AF	Frio	4,075
79		29.2	Mirando	Eoc	S	Por	3,204	3,318	10	ML	Mirando	3,312
80		22.1	Mirando	Eoc	S	Por	2,160	2,185	12	NL	Yegua	3,240

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[4]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
81	Government Wells, *Duval*	1928	7,500	600	49,691,616	2,129,527
82	Green Branch, *McMullen*	1942	0	40	Gas	Gas
83	Guerra (Cuevitas), *Starr*	1933	400	400	1,287,647	74,728
84	Haldeman, *Jim Wells*	1941	60	0	20,828	9,547
85	Hayden,[12] *Starr*	1937	0	40	Gas	
86	Henne-Winch-Farris, *Jim Hogg*	1924	720	440	3,215,987	1,123
87	Henshaw, *Jim Wells*	1940	50	40	40,664	18,281
88	Hoffman, *Duval*	1933	3,400	500	8,856,241	1,385,941
89	Holbein, *Jim Hogg*	1940	100	0	78,556	41,471
90	Holland-Hebronville (Gutierrez),[3] *Jim Hogg*	1939	10	10	1,351	0
91	Jacob (including North Jacob), *McMullen*	1926	1,230	80	1,654,980	84,243
92	Keller, *Duval*	1942	0	20	Gas	Gas
93	Kelsey, *Jim Hogg, Starr, and Brooks*	1938	2,300	160	2,000,750	251,859
94	Killam, *Webb*	1937	650	150	1,102,792	217,650
95	North Killam (including Houser), *Webb*	1938	80	20	40,794	9,689
96	Kingsville, *Kleburg*	1920	240	675	802,643	9,864
97	Kohler (including Deep Kohler), *Duval*	1926	360	5,000*y*	690,396	17,008
98	Koopman, *Jim Wells*	1942	40	40	10,993	10,993
99	Kreis, *Duval*	1940	160	0	70,783	47,523
100	Labbe, *Duval*	1934	200	500	426,197	46,981
101	La Blanca, *Hidalgo*	1936	0	3,250*y*	0	0
102	La Gloria, *Jim Wells and Brooks*	1939	40	1,640	58,126	31,001
103	La Reforma, *Starr*	1938	40	120	11,748	6,392
104	South La Reforma, *Starr*	1939	0	40	Gas	
105	Las Animas, *Jim Hogg*	1937	280	160	58,300	13,480

TABLE 1.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells							Oil-production Methods, Crude, End of 1942		Number of Crude-oil Operators in Field, End 1942
			Completed to End of 1942	During 1942	Capable of Producing Gas[6]	End of 1942			Number Wells Producing Crude Oil	Number of Wells		
				Completed		Producing Gas	Gas Wells Capable of Producing Distillate	Producing Distillate		Flowing	Artificial Lift	
81	0	30,650	835	3[8]	5	2	0	0	639	1	638	34
82	0	89,374	1	1	1	1	0	0	0	0	0	0
83	0	0	21	0	5	0	0	0	12	9	3	1
84	0	0	2	0	0	0	0	0	2	1	1	1
85	0	0	2	0	0	0	0	0	0	0	0	0
86	0	0	181	0	0	0	0	0	1	0	1	1
87	0	0	4	1	2	0	1	0	2	1	1	2
88	0	969,841	385	8	15	7	2	0	337	4	333	12
89	0	0	10	0	0	0	0	0	10	0	10	3
90	0	0	2	0	0	0	0	0	0	0	0	0
91	0	0	129	0	0	0	0	0	71	0	71	5
92	0	Gas	1	1	1	0	0	0	0	0	0	0
93	199	25,401	120	1	4	1	2	1	110	110	0	6
94	0	0	133	5	y	0	0	0	88	0	88	5
95	0	0	7	0	0	0	0	0	4	0	4	1
96	0	5,783	20	1	2	0	0	0	2	1	1	1
97	0	714,203	95	3	8	6	0	0	9	8	1	2
98	0	0	2	2	1	0	0	0	1	1	0	1
99	0	0	9	1	0	0	0	0	9	0	9	3
100	0	607,709	31	0	9	4	1	0	12	2	10	4
101	9,257 51,316[26]	10,033,897	10y	0	8	6	8	6	0	0	0	0
102	2,008,324[26]	71,356,640	41y	4	41	27	41	27	2	2	0	1
103	421	56,499	5	0	4	1	4	0	1	1	0	1
104	0	0	1	0	1	0	1	0	0	0	0	0
105	0	78,960	11	1	4	1	0	0	7	1	6	1

[26] Condensate, gasoline, kerosene, etc., obtained from gas during recycling operations.

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[a]								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
81		Gas	Cole	Eoc	S	Por	1,550	1,575	17	NFL	Mt. Selman	5,858
		20.8	Hockleyensis	Eoc	S	Por	1,776	1,825	7			
		21.6–23	Govt. Wells	Eoc	S	Por	2,200	2,380	19			
		26	Mirando	Eoc	S	Por	2,400	2,450	11			
		26–36.2	Yegua	Eoc	S	Por	2,936	2,985	4*y*			
82		Gas	Wilcox	Eoc	S	Por	5,720	5,726	6	*y*	Navarro	7,623
83		34.5	Cole	Eoc	S	Por	1,745	1,785	10	MF	Yegua	3,600
		32	McElroy	Eoc	S	Por	2,047	2,055	8			
		34.5	McElroy	Eoc	S	Por	2,209	2,232	23			
84		40.3	Frio	Olig	S	Por	5,019	5,040	16	NF	Jackson	6,498
85		Gas	Frio	Olig	S	Por	1,305	1,318	13	ML	Jackson	2,644
		Gas	Hockleyensis	Eoc	S	Por	2,619	2,644	25			
86		20.2	Mirando	Eoc	S	Por	1,944	2,100	16	MFL	Yegua	3,546
87		53	Frio	Olig	S	Por	3,778	3,792	12	NF	Vicksburg	5,885
		31.1	Frio-Vicksburg	Olig	S	Por	5,133	5,144	10			
88		26–28	Hock. (Argo locally)	Eoc	S	Por	2,550	2,595	20	NL[25]	Yegua	3,800
		20–21	Govt. Wells	Eoc	S	Por	2,650	2,750	15			
		23–25	Loma Novia	Eoc	S	Por	2,775	2,900	25	Af		
		26	Cockfield	Eoc	S	Por	3,142	3,152	10			
89		24.5	Pettus	Eoc	S	Por	2,793	2,828	15	NL	Yegua	3,150
90		32.6	Loma Novia	Eoc	S	Por	3,217	3,223	6	NL	Yegua	3,731
		55	Pettus	Eoc	S	Por	3,618	3,656	15			
91		Gas	Mirando	Eoc	S	Por	780	790	8	ML	Mt. Selman	3,171
		21.5	Pettus	Eoc	S	Por	920	975	7			
		20.5	Yegua	Eoc	S	Por	1,050	1,070	8			
92		Gas	Mirando	Eoc	S	Por	2,614	2,624	10	ML*y*	Mirando	2,661
93		44.7	Frio	Olig	S	Por	4,671	4,754	15	A	Yegua	7,507
		45	Frio	Olig	S	Por	4,924	4,952	15			
		42	Govt. Wells	Eoc	S	Por	6,099	6,107	8			
		55	Jackson	Eoc	S	Por	6,420	6,440	15			
94		21	Mirando	Eoc	S	Por	1,920	2,035	12	ML	Yegua	3,011
		Gas—45	Cockfield	Eoc	S	Por	2,475	2,500	15			
95		22	Mirando	Eoc	S	Por	2,046	2,096	7	ML	Yegua	3,060
		Gas—45	Cockfield	Eoc	S	Por	2,492	2,524	23			
96		21.5	Miocene	Mio	S	Por	1,400	2,900	20	D	Frio	6,922
		22	Catahoula	Olig	S	Por	3,217	3,238	20			
97		Gas—21.5	Cole	Eoc	S	Por	1,748	1,880	12	ML	Carrizo	7,723
		Gas—21.5	Govt. Wells	Eoc	S	Por	2,438	2,500	12			
		Gas—22.5	Mirando	Eoc	S	Por	2,613	2,800	29			
98		44.5	Frio	Olig	S	Por	4,112	4,122	10	ML	Frio-Vicksburg	6,016
		Gas-Dist.	Frio	Olig	S	Por	4,690	4,692[16]	2			
99		29.2										
100		Gas	Cole	Eoc	S	Por	1,872	1,902	10	ML	Yegua	4,054
		Gas	Chernosky	Eoc	S	Por	2,453	2,460	7			
		25.4	Loma Novia	Eoc	S	Por	2,800	2,900	19			
101	PM	62	Frio	Olig	S	Por	6,650	6,683	20	D	Vicksburg	8,893
		52	Frio	Olig	S	Por	7,450	7,480	25			
		48	Frio	Olig	S	Por	7,840	7,875	20			
		56	Frio	Olig	S	Por	8,035	8,075	25			
102	PM	55	Frio	Olig	S	Por	5,888	5,990	20	A	Jackson	8,043
		55	Frio	Olig	S	Por	6,037	6,132	15			
		55	Frio	Olig	S	Por	6,180	6,205	18			
		56	Frio	Olig	S	Por	6,533	6,598	15			
		39.5-Dist.	Frio	Olig	S	Por	6,620	6,700	15			
		55	Frio	Olig	S	Por	6,780	6,820	20			
		60	Frio	Olig	S	Por	6,998	7,011	12			
		56.6	Frio	Olig	S	Por	7,066	7,088	20			
		55	Vicksburg[27]	Olig	S	Por	7,138	7,168	20			
		25	Vicksburg[27]	Olig	S	Por	7,210	7,232	20			
103		51.6	Frio	Olig	S	Por	5,917	5,969	52	AF	Jackson	7,010
		42	Vicksburg	Olig	S	Por	6,140	6,168	28			
104		51.5	Frio	Olig	S	Por	5,798	5,832	34	AF	Vicksburg	6,566
105		18.5	Cole	Eoc	S	Por	1,782	1,828	22	NL	Yegua	4,014

[25] Also gas sand in Frio at 1760 to 1780 ft.
[27] May be same sand.

TABLE 1.—*(Continued)*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[a]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
106	La Sal Vieja,[3] *Willacy*	1936	40	0	17,954	0
107	Laurel, *Webb*	1932	220	320	623,424	4,062
108	Leaseholders,[12] *Webb*	1922	10	20	25,000	0
109	Loma Alta, *McMullen*	1935	80	0	162,592	16,451
110	Loma Novia, *Duval*	1934	7,410	270	26,660,990	1,666,675
111	Loma Valdez,[3] *Webb*	1938	0	10	Gas	
112	Loma Vista, *Duval*	1936	10	10	14,601	872
113	London, *Nueces*	1937	80	40	98,361	11,893
114	Longhorn, *Duval*	1938	960	40	1,854,702	316,786
115	Lopena, *Zapata*	1934	0	1,100	Gas	Gas
116	Lopez, *Webb and Duval*	1935	3,450	240	12,421,216	985,023
117	Los Olmos, *Starr*	1925	240	310	646,344	19,249
118	Los Picachos,[11] *Duval*	1938	20	0	576	0
119	Luby (including Luby Deep), *Nueces*	1937	3,000	60	7,662,668	772,141
120	East Luby, *Nueces*	1940	0	40	Included in Luby	
121	North Luby, *Nueces*	1939	80	0	99,559	28,303
122	Lundell, *Duval*	1937	940	160	1,420,651	334,402
123	Lykes, *Webb*	1942	20	0	1,076	1,076
124	Magnolia City, *Jim Wells*	1939	120	80	158,494	19,233
125	Manila, *Jim Hogg*	1940	230	30	225,032	67,243
126	Martinez, *Zapata* (includes South Martinez)	1929	0	850	Gas	Gas
127	Mathis,[11] *San Patricio*	1924	0	100	Gas	
128	East Mathis, *San Patricio*	1939	60	40	14,706	2,535
129	McAllen (Pharr), *Hidalgo*	1938	0	360	Gas-distillate	
130	McBride,[11] *Webb*	1940	0	40	Gas	0
131	McLean, *Webb*	1942	200	0	62,083	62,083
132	Mercedes (Capsillo), *Hidalgo*	1935	0	560	Gas-distillate	
133	Mestinas, Hidalgo	1935	Included in San Salvador			
134	Midway (San Patricio)	1937	1,280	80	2,437,026	874,741
135	Minnie Bock, *Nueces*	1939	1,340	60	1,885,577	759,056
136	Mirando City, *Webb*	1921	1,430	500	9,987,546	96,061
137	Mirando Valley, *Zapata*	1921	1,000	320	1,483,752	99,518
138	Moca, *Webb*	1932	100	20	1,197,162	62,444
139	Munson, *McMullen*	1938	150	20	185,944	18,443
140	Neuhaus, *Jim Hogg*	1941	80	0	12,001	11,941
141	Nichols, *Hidalgo*	1940	280	20	182,286	118,103
142	Odem, *San Patricio*	1939	820	120	408,664	367,089

TABLE 1.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells: Completed to End of 1942	During 1942: Completed	Capable of Producing Gas[6]	End of 1942: Producing Gas	End of 1942: Gas Wells Capable of Producing Distillate	End of 1942: Producing Distillate	Number Wells Producing Crude Oil	Oil-production Methods, Crude, End of 1942, Number of Wells: Flowing	Oil-production Methods, Crude, End of 1942, Number of Wells: Artificial Lift	Number of Crude-oil Operators in Field, End 1942
106	0	0	1	0	0	0	0	0	0	0	0	0
107	0	0	33	0	0	0	0	0	4	0	4	1
108	0	0	3	0	0	0	0	0	0	0	0	0
109	0	0	4	0	0	0	0	0	3	0	3	3
110	0	65,106	758	0	4	1	0	0	554	0	554	25
111	0	0	1	0	0	0	0	0	0	0	0	0
112	0	0	2	0	0	0	0	0	1	1	0	1
113	0	0	4	0	1	0	1	0	3	0	3	2
114	0	62,523	48	0	1	1	1	0	42	28	14	3
115	0	8,463,941	23	2[8]	22	21	0	0	0	0	0	0
116	0	3,375	369	0	3	1	0	0	311	1	310	10
117	0	0	110	0	0	0	0	0	75	0	75	2
118	0	0	1	0	0	0	0	0	0	0	0	0
119	1,030	236,998	153	1	3	2	2	1	146	134	12	7
120			1	0	1	0	1	0	0	0	0	0
121	0	0	5	1	0	0	0	0	3	1	2	1
122	0	64,153	104	0	8	3	0	0	94	34	60	4
123	0	0	1	1	0	0	0	0	1	0	1	1
124	709	29,139	9	0	4	0	4	0	3	2	1	1
125	0	76,891	26	0	3	2	0	0	23	2	21	7
126	0	650,585	27	0	26	18	0	0	0	0	0	0
127	0	0	6	0	y	0	0	0	0	0	0	0
128	0	74,500	3	0	1	0	0	0	1	1	0	1
129	961	238,359	4	1	3	1	3	1	0	0	0	0
130	0	0	1	0	1	0	0	0	0	0	0	0
131	0	0	5	5	0	0	0	0	5	0	5	2
132	7,712	505,871	7	0	7	5	7	5	0	0	0	0
133				Included in San Salvador								0
134	6,431	221,966	68	11	2	1	2	1	62	52	10	13
135	274	674,830	77	8	5	3	5	0	65	27	38	15
136	0	2,860	295	0	1	1	0	0	63	0	63	4
137	0	33,403	146	0	2	1	0	0	68	2	66	4
138	0	0	12	0	0	0	0	0	11	0	11	3
139	0	0	17	0	0	0	0	0	12	0	12	4
140	0	0	2	1	0	0	0	0	2	1	1	2
141	0	0	15	3	1	0	0	0	14	10	4	3
142	0	634,973	49	31	6	1	2	0	43	42	1	2

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[9]								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
106		48	Frio	Olig	S	Por	7,630	7,646	16	D	Frio	10,286
107		Gas	Frio	Olig	S	Por	360	366	6	MFL	Cook Mt.	3,165
		Gas	Mirando	Eoc	S	Por	1,770	1,777	6			
		49	Cockfield	Eoc	S	Por	2,211	2,275	7			
108		22	Cole[28]	Eoc	S	Por	1,000	1,055	6	ML	Yegua	3,034
109		21	Chernosky	Eoc	S	Por	2,195	2,250	12	MFL	Cockfield	2,766
110	RP	23.9–26	Loma Novia	Eoc	S	Por	2,550	2,705	25	ML	Cook Mt.	4,200
		22	Mirando	Eoc	S	Por	2,846	2,900	15			
111		Gas	Cole	Eoc	S	Por	1,790	1,812	19	NL	Yegua	3,528
112		25.7	Loma Novia	Eoc	S	Por	2,914	2,922	7	ML	Cook Mt.	4,732
113		24.4	Catahoula	Olig	S	Por	4,698	4,730	8	NF	Frio	7,424
		51	Catahoula	Olig	S	Por	4,752	4,906	10			
114		41.7	Cole	Eoc	S	Por	4,009	4,100	10	AFL	Yegua	6,011
		45.7	Govt. Wells	Eoc	S	Por	4,885	4,914	10			
115		Gas	Queen City	Eoc	S	Por	2,137	2,180	20	A	Mt. Selman	3,707
		Gas	Queen City	Eoc	S	Por	2,416	2,462	20			
		Gas	Queen City	Eoc	S	Por	2,495	2,535	20			
116		20.7	Mirando	Eoc	S	Por	2,126	2,250	18	ML	Yegua	3,437
117		20	Frio	Olig	S	Por	250	700	17	MF	Yegua	2,612
118		24	Govt. Wells	Eoc	S	22–26	2,166	2,196	15	MF	Govt. Wells	2,196
119	PM	45.7	Catahoula	Olig	S	Por	4,306	4,354	15	AF	Frio	7,595
		45.7	Heterostegina	Olig	S	Por	5,009	5,087	20			
		45.7	Heterostegina	Olig	S	Por	5,150	5,175	10			
		37.2	Frio	Olig	S	Por	7,308	7,313	5			
120		56	Oakville	Mio	S	Por	4,023	4,038	15	AF	Frio	7,628
121		48	Catahoula	Olig	S	Por	4,347	4,370	14	AF	Frio	9,110
		45.7	Heterostegina	Olig	S	Por	5,073	5,085	12			
122		19.3	Cole	Eoc	S	Por	1,500	1,530	10	MFL	Jackson	2,698
123		45	Mirando	Eoc	S	Por	1,950	1,968	14	ML*y*	Yegua	2,638
124		42.7	Frio	Olig	S	Por	5,436	5,485	10	A	Jackson	6,592
		Gas	Frio	Olig	S	27.7	5,561	5,569	8			
		40.8	Frio	Olig	S	Por	5,692	5,726	10			
125		24.9	Pettus	Eoc	S	Por	2,541	2,650	10	NL	Yegua	3,006
126		Gas	McElroy	Eoc	S	Por	1,860	1,927	6	ML	Cook Mt.	3,514
127		Gas	Catahoula	Olig	S	Por	2,375	2,414	10	MF	Jackson	5,526
128		54	Frio	Olig	S	Por	4,417	4,422	5	NF	Jackson	
		35.5	Frio	Olig	S	Por	5,258	5,270	12			
		41	Vicksburg	Olig	S	Por	5,600	5,627	10			
129		61.5	Frio	Olig	S	Por	5,970	5,994	24	AF	Vicksburg	8,575
		56–60	Frio	Olig	S	Por	6,500	7,087	20			
		53	Frio	Olig	S	Por	7,415	7,570	25			
130		Gas	Mirando	Eoc	S	Por	2,525	2,539	14	ML	Yegua	3,470
131		55	Lower Yegua	Eoc	S	Por	3,238	3,253	15	*y*	Cook Mt.	4,016
132		49.2–61	Frio	Olig	S	Por	7,430	7,524	16	DF	Vicksburg	9,618
		50–60	Frio-Vicksburg	Olig	S	Por	7,500	9,500	15			
133		52–60	Frio	Olig	S	Por	6,658	6,748	90	A	Frio	8,123
134		28.4	Heterostegina	Olig	S	Por	5,285	5,370	15	Af	Frio	8,503
		46.5	Frio	Olig	S	Por	6,048	6,100	15			
		42.3	Frio	Olig	S	Por	6,255	6,280	25			
135		Gas—24.5	Catahoula	Olig	S	Por	3,652	3,712	14	AF	Frio	7,510
		Gas—23.5	Catahoula	Olig	S	Por	3,785	3,900	15			
		55	Frio	Olig	S	Por	5,510	5,518	8			
136		20.6	McElroy	Eoc	S	Por	1,530	1,540	10	ML	Mt. Selman	5,000
		45	Cockfield	Eoc	S	Por	1,925	1,935	10			
137		20.9	McElroy	Eoc	S	Por	1,400	1,450	7	ML	Cook Mt.	3,660
		20.9	Mirando	Eoc	S	Por	1,790	2,000	10			
138		21	Mirando	Eoc	S	Por	900	950	10	MFL	Yegua	2,178
139		20.7–22.5	Mirando	Eoc	S	Por	1,200	1,215	12	ML	Pettus	1,501
140		47.6	Pettus	Eoc	S	Por	3,454	3,471	9	MF*y*	Pettus	3,471
141		Gas	Frio	Olig	S	Avg. = 30	3,132	3,138	6	AF	Jackson *y*	4,528
		26	Frio	Olig	S		3,481	3,515	10			
		34.7	Frio	Olig	S		3,670	3,678	8			
		37.6	Frio	Olig	S		3,869	3,929	8			
142		56	Catahoula	Olig	S	Por	3,512	3,548	15	AF	Frio	7,411
		31.5–42	Frio	Olig	S	Por	5,265	5,445	15			
		37.3–57	Frio	Olig	S	Por	6,715	6,758	8			
		38.2–57	Frio	Olig	S	Por	6,900	7,000	15			

[28] Also gas sand in Frio at 270 ft.

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[4]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
143	Oilton, *Webb*	1937	525	60	1,654,890	97,209
144	Orange Grove, *Jim Wells*	1940	1,040	100	1,117,809	534,222
145	Palacios,[3,29] *Jim Hogg*	1941	0	20	Gas	
146	Palangana,[3v] *Duval*	1928	50	0	9,846	0
147	Palo Blanco,[3] *Brooks*	1929	0	80	Gas-spray	
148	Patal,[11] *Jim Hogg*	1940	0	40	Gas	
149	Pena,[11] *Duval*	1933	0	40	Gas	
150	Penitas, *Hidalgo*	1942	0	40	Gas-distillate	
151	Peters, *Duval*	1933	140	1,400	235,487	24,675
152	East Peters, *Duval*	1940	60	0	27,019	7,583
153	Petronilla, *Nueces*	1941	100	20	42,925	29,013
154	Peyote,[11] *Jim Hogg*	1932	0	20	Gas	
155	Piedre Lumbre, *Duval*	1935	1,300	200	3,190,675	547,515
156	Pietras Pintas, *Duval*	1905	150	0	154,183	0
157	Plymouth, *San Patricio*	1935	3,750	150	25,700,125	2,765,051
158	East Plymouth, *San Patricio*	1938	0	160	Gas-distillate	
159	Premont (including Southeast Premont), *Jim Wells*	1933	720	280	837,831	44,529
160	South Premont, *Jim Wells*	1942	0	40	Gas-distillate	
161	Quinto Creek, *Jim Wells*	1942	80	40	14,226	14,226
162	Ramirez,[11] *Jim Hogg*	1941	0	20	Gas	
163	Rancho Solo (including Rancho Solo Extension), *Duval*	1935	440	160	444,337	55,544
164	Randado, *Jim Hogg*	1926	765	435	4,860,075	69,044
165	Reiser,[10] *Webb*	1909	20	1,270	4,000	0
166	Reynolds, *Jim Wells*	1939	690	0	1,203,424	219,966
167	Rhode, *McMullen*	1936	0	1,200	Gas	Gas
168	Ricaby (including North Ricaby), *Starr*	1937	150	0	129,497	15,921
169	Richard King (East Bentonville), *Nueces*	1937	1,460	140	1,940,429	630,592
170	Rincon, *Starr*	1938	4,000	280	3,699,965	1,776,968
171	North Rincon, *Starr*	1940	220	40	129,283	42,748
172	Rio Grande City, *Starr*	1932	200	60	441,553	28,376
173	Rios, *Duval*	1941	0	20	Gas-distillate	

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[29] Considered to be part of Randado field by Railroad Commission.

TABLE 1.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells						Number Wells Producing Crude Oil	Oil-production Methods, Crude, End of 1942		Number of Crude-oil Operators in Field, End 1942
			Completed to End of 1942	During 1942	Capable of Producing Gas[6]	End of 1942				Number of Wells		
				Completed		Producing Gas	Gas Wells Capable of Producing Distillate	Producing Distillate		Flowing	Artificial Lift	
143	0	0	141	0	0	0	0	0	68	0	68	10
144	37	30,000	40	9[8]	1	0	0	0	36	30	6	10
145	0	0	1	0	1	0	0	0	0	0	0	0
146	0	0	5	0	0	0	0	0	0	0	0	0
147	0	0	5	0	1	0	0	0	0	0	0	0
148	0	0	1	0	1	0	0	0	0	0	0	0
149	0	0	1	0	0	0	0	0	0	0	0	0
150	*y*	2,180	1	1	1	0	1	0	0	0	0	0
151	0	1,288,549	21	0	13	7	0	0	4	1	3	2
152	0	0	4	0	0	0	0	0	4	1	3	2
153	0	0	6	4	0	0	0	0	5	5	0	2
154	0	0	1	0	0*y*	0	0	0	0	0	0	0
155	0	1,495	144	1	3	0	0	0	130	9	121	4
156	0	0	29	0	0	0	0	0	0	0	0	0
157	762	151,542	198	3	6	2	1	1	185	171	14	11
158	950	323,743	4	0	4	1	4	0	0	0	0	0
159	0	32,443	63	0	8	1	3	0	20	2	18	7
160	*y*	*y*	1	1	1	0	1	0	0	0	0	0
161	199	39,000	3	3	1	0	1	0	2	2	0	1
162	0	0	1	0	1	0	0	0	0	0	0	0
163	0	0	45	1	0	0	0	0	35	0	35	8
164	0	0	191	0	1	0	0	0	82	0	82	5
165	0	0	18	0	0	0	0	0	0	0	0	0
166	0	968	32	0	2	1	2	0	26	19	7	4
167	0	1,501,615	11	0	10	9	0	0	0	0	0	0
168	0	0	14	0	0	0	0	0	9	0	9	2
169	2,191	226,123	77	7	3	2	2	1	72	65	7	1
170	3,039[30]	209,588	155	29	10	5	10	0	143	138	5	3
171	1,954	227,274	14	1	2	2	2	2	10	7	3	1
172	0	0	34	0	0	0	0	0	20	0	20	3
173	95	15,799	1	0	1	0	1	0	0	0	0	0

[30] Condensate obtained during repressuring operations.

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[c]	Character of Oil	Producing Formation[d]								Deepest Zone Tested to End of 1942	
							Depth, Avg. Ft.					
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
143		22	Mirando	Eoc	S	Por	1,880	2,025	12	ML	Yegua	3,151
		Gas	Cockfield	Eoc	S	Por	2,407	2,473	15			
144		Gas	Frio	Olig	S	Por	3,292	3,308	16	NF	Jackson	6,012
		30.6-32	Frio	Olig	S	Por	5,048	5,125	15			
145		Gas	Yegua	Eoc	S	Por	2,924	2,939	15	NL	Yegua	3,008
146		16	Catahoula	Olig	L	Cav	450	455	5	Ds	Mt. Selman	5,454
		45	Jackson	Eoc	S	Por	2,730	2,744	14			
147		Gas	Oakville	Mio	S	Por	1,200	1,220	10	Dsy	Cockfield	6,603
		Gas—45	Jackson	Eoc	S	Por	4,117	4,150	10			
148		Gas	Yegua	Eoc	S	Por	3,120	3,130	10	MF	Yegua	3,156
149		Gas	Frio	Olig	S	Por	1,910	1,932	17	MFL	Cockfield	3,620
150		Gas—60.9	Frio y	Olig	S	Por	6,020	6,026[16]	6	y	Vicksburg y	6,802
151		Gas	Cole	Eoc	S	Por	1,750	1,760	5	ML	Cook Mt.	4,004
		23.1	Govt. Wells	Eoc	S	Por	2,410	2,451	20			
		23.1	Mirando	Eoc	S	Por	2,566	2,635	15			
152		22.9	Govt. Wells	Eoc	S	Por	2,441	2,465	13	ML	Mirando	2,563
153		44	Frio	Olig	S	Por	6,952	6,968	10	NF	Frio	8,149
		40	Frio	Olig	S	Por	7,308	7,315	7			
154		Gas	Govt. Wells	Eoc	S	Por	2,246	2,262	16	ML	Yegua	3,210
155		20	Cole	Eoc	S	Por	1,324	1,362	7	ML	Midway	10,931
		21.7-22.7	Govt. Wells	Eoc	S	Por	1,950	2,080	12			
		20.4	Loma Novia	Eoc	S	Por	2,100	2,174	10			
156		13	Catahoula	Olig	S	Por	180	580	20	Ds	Mt. Selman	5,902
		47	McElroy	Eoc	S	Por	3,462	3,623	26			
157	PM	29.8-31.4	Frio	Olig	S	Por	5,458	5,525	10	AF	Frio	7,253
		31.7-34.2	Frio	Olig	S	Por	5,578	5,675	12			
		31.6-62	Frio	Olig	S	Por	5,870	5,920	10			
		40	Frio	Olig	S	Por	6,136	6,159	10			
158		Gas	Heterostegina	Olig	S	Por	4,808	4,836	20	AF	Frio	7,287
		Gas	Frio	Olig	S	28-34	5,110	5,136	15			
159		22.8	Catahoula	Olig	S	Por	2,250	2,350	10	D	McElroy	7,155
		24	Frio	Olig	S	Por	3,165	3,265	11			
		23	Frio	Olig	S	Por	3,706	3,716	10			
160		Distillate	Frio	Olig	S	Por	6,040	6,067	18	y	Vicksburg y	7,631
161		29	Frio	Olig	S	Por	4,860	4,870	10	NFy	Jackson	5,900
		Gas-Dist.	Vicksburg	Olig	S	Por	5,067	5,083	16			
162		Gas	Mirando	Eoc	S	Por	1,992	2,006	10	ML	Yegua	3,006
163		19.4	Cole	Eoc	S	Por	1,800	1,895	12	ML	Yegua	3,777
		Gas	Govt. Wells	Eoc	S	Por	2,555	2,569	14			
164		22.5	Cole	Eoc	S	Por	1,220	1,300	9	NL	Mt. Selman	5,222
165		16	Jackson-Cockfield	Eoc	S	Por	390	1,010	15	ML	Mt. Selman	3,247
166		38	Frio	Olig	S	Por	3,145	3,155	10	ANL	Jackson	6,025
		20.4	Frio	Olig	S	Por	4,753	4,928	10			
		38	Frio	Olig	S	Por	5,100	5,254	9			
167		Gas	Cole	Eoc	S	Por	1,800	1,822	12	MFL	Yegua	3,534
168		21.2	Frio	Olig	S	Por	1,270	1,324	8	NL	Jackson	2,844
		21.2	Frio	Olig	S	Por	1,432	1,456	5			
		30	Frio	Olig	S	Por	1,604	1,611	7			
169		22	Heterostegina	Olig	S	Por	3,800	4,030	15	AF	McElroy	7,567
		37	Frio	Olig	S	Por	5,250	5,270	7			
		39	Frio	Olig	S	Por	5,350	5,466	15			
		38.8-42	Frio	Olig	S	Por	5,595	5,750	10			
		38	Vicksburg	Olig	S	Por	6,133	6,143	10			
		56	Vicksburg	Olig	S	Por	6,230	6,235	5			
170	PM	38.7-40.1	Frio	Olig	S	Por	3,629	3,797	20	A	Yegua	6,862
		39.7-44	Frio	Olig	S	Por	3,855	4,046	18			
		42.6-45.1	Frio-Vicksburg	Olig	S	26-39	4,086	4,294	20			
171		44.6	Frio	Olig	S	Por	4,111	4,212	18	A	Jackson	5,590
		42.5	Vicksburg	Olig	S	Por	4,370	4,404	9			
		52	Vicksburg	Olig	S	Por	4,592	4,670	15			
		41.9	Vicksburg	Olig	S	Por	4,725	4,745	15			
		47.5	Jackson	Eoc	S	Por	5,478	5,590	15			
172		23	Frio	Olig	S	Por	1,350	1,450	8	MFL	Yegua	3,258
173		51.2	McElroy	Eoc	S	Por	6,270	6,308	15	NFy	McElroy	6,308

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[a]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
174	Riverside, *Nueces*	1938	80	80	111,538	23,876
175	Robston, *Nueces*	1939	60	0	80,575	14,644
176	Roma, *Starr*	1927	20	280	15,119	187
177	Roth, *Jim Wells*	1942	0	20	Gas	Gas
178	Sacatosa,[3] *Starr*	1938	0	20	Gas	
179	Sam Fordyce (including North Sam Fordyce) *Hidalgo and Starr*	1934	1,600	900	7,549,424	130,440
180	Sandia, *Jim Wells*	1929	80	400	21,561	382
181	San Diego,[11] *Jim Wells*	1934	0	320	Gas	
182	San Jose,[11] *McMullen*	1938	10	10	450	0
183	San Salvador, *Hidalgo* (includes Mestmas)	1938	0	1,200	Gas-distillate	Gas-distillate
184	Santo Domingo,[11] *Starr*	1936	0	120	Gas	
185	Sarnosa, *Duval*	1932	690	180	2,656,587	117,950
	Saxet, *Nueces*	1923				
186	Shallow	1923	3,850	3,800	43,112,372	1,363,644
187	Deep (Frio)	1935	2,450	3,400	8,209,446	1,135,190
188	Seeligson (East Premont), *Jim Wells and Kleburg*	1937	3,680	200	686,839	257,072
189	Sejita, *Duval*	1939	40	320	8,456	8,456
190	Seven Sisters, *Duval*	1934	4,420	280	17,589,038	2,072,580
191	South Seven Sisters, *Duval*	1937	330	0	680,697	47,963
192	Shield, *Nueces*	1940	220	60	213,050	104,810
193	Sinton, *San Patricio*	1934	225	100	57,179	0
194	South Sinton, *San Patricio*	1942	0	40	Gas distillate	
195	Southland, *Duval*	1939	120	40	127,409	24,681
196	Stratton (including East Stratton), *Nueces Kleburg, Jim Wells*	1931	2,500	2,500	1,323,788	666,924

TABLE I.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells							Oil-production Methods, Crude, End of 1942		Number of Crude-oil Operators in Field, End 1942
			Completed to End of 1942	During 1942	Capable of Producing Gas[6]	End of 1942			Number Wells Producing Crude Oil	Number of Wells		
				Completed		Producing Gas	Gas Wells Capable of Producing Distillate	Producing Distillate		Flowing	Artificial Lift	
174	0	2,096	6	0	3	1	2	0	2	2	0	1
175	0	0	3	0	0	0	0	0	3	3	0	3
176	0	0	6	0	5	0	0	0	0	0	0	0
177	0	y	1	1	1	0	0	0	0	0	0	0
178	0	0	1	0	1	0	0	0	0	0	0	0
179	0	0	259	0	1	0	0	0	57	3	54	3
180	5,990	878,246	9	0	3	2	3	2	2	0	2	1
181	0	0	2	0	2y	0	0	0	0	0	0	0
182	0	0	2	0	1	0	0	0	0	0	0	0
183	2,205 61,745[30]	11,405,079	7	0	7	5	7	5	0	0	0	0
184	0	0	2	0	2y	0	0	0	0	0	0	0
185	0	0	57	0	0	0	0	0	37	0	37	4
186	1,988	14,600,377	761	0	89	63	10	5	256	31	225	37
187	86,537	8,207,195		0	36	11	35	9	90	25	65	18
188	27,751	1,286,647	97	57y[8]	5	4	4	4	92	92	0	5
189	1,974	125,000	9	3	6	1	6	0	1	1	0	1
190	0	1,465,284	461	3	10	9	3	0	391	4	387	20
191	0	0	33	0	0	0	0	0	28	0	28	3
192	18,684	358,177	14	1	4	3	4	3	10	7	3	2
193	1,753	205,153	7	0	2	2	2	2	0	0	0	0
194	y	y	1	1	1	0	1	0	0	0	0	0
195	2,391	442,410	5	0	1	1	1	1	3	3	0	1
196	32 711,247[32]	54,686,458	183y	56	58	39	58	39	125	125	0	9

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[32] Condensate, gasoline, kerosene, etc., obtained from gas during recycling operations.

TABLE 1.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[c]								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
174		32.2	Frio	Olig	S	Por	4,888	5,037	25	A	Vicksburg	7,750
		55	Frio	Olig	S	Por	6,970	6,975	5			
175		41.9	Frio	Olig	S	Por	5,195	5,208	12	A	Frio	7,525
		51.9	Frio	Olig	S	Por	5,548	5,650	20			
176		Gas	Jackson	Eoc	S	Por	192	200	8	A	Reklaw	4,827
		35.2	Queen City	Eoc	S	Por	3,560	3,650	6			
177		Gas	Frio	Olig	S	Por	3,245	3,275	15*y*	N	Vicksburg	5,405
178		Gas	Govt. Wells	Eoc	S	Por	1,650	1,661	11	ML	Govt. Wells	1,794
179		21.5	Frio	Olig	S	Por	2,737	2,793	16	AF	Mt. Selman	9,708
		24.9	Frio	Olig	S	Por	2,831	2,890	22			
		24.9	Frio	Olig	S	Por	2,925	3,125	20			
		Gas	Frio	Olig	S	Por	3,183	3,196	13			
		Gas	Jackson	Eoc	S	Por	5,840	5,900	20			
180		Gas	Catahoula	Olig	S	Por	2,910	2,917	7	AF	McElroy	5,701
		38.3	Frio	Olig	S	Por	4,002	4,023	13			
		52	Cole	Eoc	S	Por	5,151	5,163	10			
181		Gas	Frio	Olig	S	Por	2,952	2,976	10	A	Yegua	6,480
182		23	Cole	Eoc	S	Por	1,147	1,163	16	ML	Yegua	2,370
183		48.8–58	Frio	Olig	S	Por	7,315	7,645	15	A	Vicksburg	8,704
		49.7	Frio-Vicksburg	Olig	S	Por	8,174	8,704	15			
184		Gas	Frio	Olig	S	Por	2,461	2,616	25	A	Cook Mt.	6,005
185		21.3	Govt. Wells	Eoc	S	Por	2,300	2,500	15	MFL	Yegua	4,073
186		24	Lagarto-Oakville	Plio-Mio	S	Por	1,000	3,150	15	DF	Vicksburg	10,892
		24	Catahoula	Olig	S	29–42	3,900	4,500	18			
		31.7	Discorbis-Het.	Olig	S	Por	4,700	4,880	18			
187		30.6–42.6	Frio	Olig	S	Por	5,280	6,900	20			
		56	Frio	Olig	S	Por	7,250	7,548	20			
		58	Frio-Vicksburg	Olig	S	Por	9,900	9,927	20			
188		39.9	Frio	Olig	S	Por	5,193	5,275	12	A	Vicksburg	8,162
		54–60	Frio	Olig	S	Por	5,365	5,480	10			
		40	Frio	Olig	S	Por	5,555	5,557[16]	2*y*			
		36–60	Frio	Olig	S	Por	5,625	5,632	10			
		39.9	Frio	Olig	S	Por	5,805	5,850	15			
		40–43.6	Frio	Olig	S	Por	5,878	6,000	20			
		39.9–42.8	Frio	Olig	S	Por	6,016	6,138	20			
		55	Frio	Olig	S	Por	6,420	6,448	10			
		38.1	Frio	Olig	S	Por	6,534	6,697	10			
189		51.7	McElroy	Eoc	S	Por	5,334	5,395	15	AF	Yegua	7,095
		52–55	McElroy	Eoc	S	Por	5,476	5,675	15			
		43.1–54	McElroy	Eoc	S	Por	5,770	5,830	20			
190		Gas	Frio	Olig	S	Por	1,232	1,262	15	AFL	Cook Mt.	4,404
		21	Cole	Eoc	S	Por	1,710	1,720	10			
		20.9	Chernosky	Eoc	S	Por	2,112	2,250	20			
		23	Govt. Wells	Eoc	S	Por	2,470	2,500	15			
		27	Loma Novia[31]	Eoc	S	Por	2,660	2,690	15			
		23	Mirando	Eoc	S	Por	2,540	2,565	10			
		Gas	Yegua	Eoc	S	Por	3,037	3,071	15			
191		21.5	Frio	Olig	S	Por	1,487	1,566	7	AFL	Yegua	3,100
		23	Loma Novia	Eoc	S	Por	2,643	2,656	10			
192		44.3	Frio	Olig	S	Por	6,600	6,657	15	AF	Frio	7,806
		56	Frio	Olig	S	Por	6,970	6,980	10			
193		33.4–47	Frio	Olig	S	Por	5,408	5,641	15	A	Frio	7,438
		33	Frio	Olig	S	Por	5,880	5,905	10			
194		53.9	Frio	Olig	S	Por	6,663	6,682	19	A*y*	Frio	6,687
195		48.1	Pettus	Eoc	S	Por	5,286	5,298	10	AFL	Yegua	6,015
		43.8	Pettus	Eoc	S	Por	5,355	5,365	10			
196	PM	58	Frio	Olig	S	Por	4,788	4,924	15	AF	Vicksburg	8,138
		49.3	Frio	Olig	S	Por	5,992	6,002	10			
		43–54	Frio	Olig	S	Por	6,273	6,460	20			
		42.2–54	Frio	Olig	S	Por	6,465	6,647	20			
		35.5–43	Frio	Olig	S	Por	6,658	6,770	20			
		54	Frio	Olig	S	Por	6,804	6,823	15			

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[31] Stratigraphically higher than Mirando. Variance in depths due to surface elevations.

TABLE I.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Crude Oil Production, Bbl.[4]	
			Oil	Distillate and/or Gas[b]	To End of 1942	During 1942
197	Sullivan (South Agua Dulce),[12] *Nueces*	1936	Included in Agua Dulce			
198	Sullivan City, *Hidalgo and Starr*	1939	780	160	488,698	144,682
199	Sun, *Starr*	1938	1,660	100	1,130,806	261,816
200	North Sun, *Starr*	1941	320	0	25,770	25,102
201	Sun-Jones (Jones), *Jim Hogg*	1941	0	20	Gas	
202	Sweden, *Duval*	1937	200	160	250,870	19,694
203	Taft, *San Patricio*	1935	720	80	5,348,144	360,083
204	Tarancahuas, *Duval*	1939	290	0	409,593	108,795
205	Tesoro (DeSoto), *Duval*	1938	140	80	208,767	6,428
206	Thomas Lockhart,[12] *Duval*	1937	100	0	17,146	0
207	Turkey Creek (West Saxet), *Nueces*	1938	890	40	4,341,819	549,985
208	Ulrich, *Starr*	1942	20	0	[y]	[y]
209	Villa,[11] *Zapata*	1932	0	120	Gas	
210	Volpe, *Webb*	1939	330	10	477,112	123,678
211	Wade City, *Jim Wells*	1939	2,000	200	2,917,356	1,124,775
212	Washburn, *LaSalle*	1940	400	0	97,235	77,559
213	Wentz,[7y] *McMullen*	1932	0	80	Gas	
214	Weslaco,[3y] *Hidalgo*	1938	0	40	Gas	
215	White Point, *San Patricio*	1911	100	3,900	155,872	23,985
216	East White Point, *San Patricio and Nueces*	1938	4,360	180	11,166,277	2,860,346
217	Willamar, *Willacy*	1940	275	0	77,118	26,477
218	Woods,[11] *Starr*	1936	0	120	Gas	
219	Wray,[11] *Zapata*	1933	0	80	Gas	
220	Young (Charco Blanco), *Starr*	1938	0	20	Gas	
221	Yturria, *Starr*	1941	440	40	60,330	52,026
222	Yzaguirre, *Starr*	1940	20	20	5,357	979
223	Zim (Seabury), *Starr*	1939	10	10	472	20
224	Total		138,705	84,800	407,711,494	39,234,738

TABLE 1.—(*Continued*)

Line Number	Total Distillate[4] Production, Bbls. During 1942	Total Gas[4] Production, Millions Cu. Ft. During 1942	Number of Oil and/or Gas Wells: Completed to End of 1942	Number of Oil and/or Gas Wells: During 1942: Completed	Number of Oil and/or Gas Wells: Capable of Producing Gas[6]	Number of Oil and/or Gas Wells: End of 1942: Producing Gas	Number of Oil and/or Gas Wells: End of 1942: Gas Wells Capable of Producing Distillate	Number of Oil and/or Gas Wells: End of 1942: Producing Distillate	Number of Oil and/or Gas Wells: Number Wells Producing Crude Oil	Oil-production Methods, Crude, End of 1942: Number of Wells: Flowing	Oil-production Methods, Crude, End of 1942: Number of Wells: Artificial Lift	Number of Crude-oil Operators in Field, End 1942
197				Included in Agua Dulce								
198	1,378	553,590	39	0	5	3	3	1	33	24	9	5
199	7,723	585,250	87	12	5	2	4	2	82	79	3	4
200	0	0	9	7	0	0	0	0	9	9	0	1
201	0	0	1	0	1	0	0	0	0	0	0	0
202	850	79,174	15	0	2	1	2	1	5	2	3	1
203	0	60,843	74	0	2	1	1	0	69	46	23	6
204	0	0	29	0	0	0	0	0	29	1	28	2
205	0	0	8	0	1	0	1	0	2	2	0	1
206	0	0	4	0	0	0	0	0	0	0	0	
207	0	223,282	60	0	4	1	4	0	53	37	16	5
208	0	0	1	1	0	0	0	0	1y	1y	0	1
209	0	0	3	0	y	0	0	0	0	0	0	0
210	0	0	34	0	0	0	0	0	28	0	28	2
211	1,091	325,682	106	2	12	5	6	2	94	80	14	17
212	0	235,182	11	7	3	1	1	0	10	8	2	1
213	0	0	3	0	y	0	0	0	0	0	0	0
214	0	0	1	0	1	0	1	0	0	0	0	0
215	3,458	1,567,476	48	0	8	3	2	1	1	0	1	1
216	23,986	2,482,052	246	0	7	4	4	2	236	232	4	17
217	0	0	7	2	0	0	0	0	7	7	0	1
218	0	0	4	0	y	0	0	0	0	0	0	0
219	0	0	3	0	y	0	0	0	0	0	0	0
220	0	3,463	1	0	1	1	0	0	0	0	0	0
221	0	0	12	8	0	0	0	0	12	12	0	1
222	0	0	2	0	1y	0	0	0	1	0	1	1
223	0	0	2	0	1y	0	0	0	1	1	0	1
224	5,559,377	328,208,837	13,732	471[33]	1,022	478	512	221	8,429	2,771	5,658	

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[33] Also two completions in the San Patricio County part of Rooke field.

TABLE I.—(*Continued*)

Line Number	Repressuring Operation[d]	Character of Oil	Producing Formation[9]								Deepest Zone Tested to End of 1942	
		Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
							Top Prod. Zone	Bottoms Prod. Wells				
197		51	Frio	Olig	S	Por	5,756	5,780	15	AF	Frio	6,912
		Gas-dist.	Frio	Olig	S	Por	6,400	6,668	15			
		Gas-dist.	Frio	Olig	S	Por	6,788	6,800	12			
198		24	Frio	Olig	S	Por	3,414	3,463	15	AF	Mt. Selman	9,708
		39.4	Frio	Olig	S	Por	3,936	3,983	25			
		43.6	Frio	Olig	S	Por	4,121	4,130	9			
199		52	Frio	Olig	S	Por	4,111	4,142	15	A	Jackson	6,113
		47	Frio	Olig	S	Por	4,500	4,565	20			
		46–62	Frio	Olig	S	Por	4,595	4,700	15			
		45.2	Frio	Olig	S	Por	4,842	4,858	16			
		45.1	Frio	Olig	S	Por	4,900	4,972	10			
		47.9	Vicksburg	Olig	S	Por	5,115	5,135	20			
200		46.6	Frio	Olig	S	Por	4,507	4,550	20	A	Jackson	6,607
		46.7	Vicksburg	Olig	S	Por	5,376	5,396	20			
201		Gas	Hockleyensis	Eoc	S	Por	4,211	4,268	15	MLy	Yegua	6,009
202		43	Chernosky	Eoc	S	Por	4,895	4,939	20	AFL	Yegua	7,005
		46	Upper Govt. Wells	Eoc	S	Por	5,072	5,091	19			
		Gas	Lower Govt. Wells	Eoc	S	Por	5,100	5,116	16			
		43	Cockfield	Eoc	S	Por	5,845	5,869	24			
203		21.4	Catahoula	Olig	S	Por	3,975	4,010	20	MF	Frio	6,926
		21.6	Catahoula	Olig	S	Por	4,300	4,375	20			
		23	Heterostegina	Olig	S	Por	4,900	4,938	20			
204		21.1	Frio	Olig	S	Por	2,014	2,105	15	NFL	Yegua	3,461
205		Gas	Pettus	Eoc	S	Por	4,828	4,848	15	NF	Yegua	5,541
		41.8–45	Yegua	Eoc	S	Por	5,080	5,136	20			
206		56.8	Pettus	Eoc	S	Por	4,659	4,672	13	MF	Yegua	5,502
207		22.6	Catahoula	Olig	S	Por	3,840	3,860	14	DF	Frio	7,511
		25	Catahoula	Olig	S	Por	4,025	4,080	10			
		43	Frio	Olig	S	Por	5,641	5,664	19			
		35	Frio	Olig	S	Por	5,787	5,872	19			
		28	Frio	Olig	S	Por	6,430	6,456	26			
208		45.8	Frio	Olig	S	Por	3,965	3,972	7	Ny	Vicksburg	4,200
209		Gas	McElroy	Eoc	S	Por	1,650	1,664	7	ML	Cook Mt.	3,000
210		27	Mirando	Eoc	S	Por	2,450	2,488	10	MFL	Yegua	3,717
211		50	Frio	Olig	S	Por	3,283	3,302	15	NFL	Jackson	5,415
		31–51	Frio	Olig	S	Por	4,763	4,820	10			
		32.2	Vicksburg	Olig	S	Por	4,894	4,933	10			
		55	Vicksburg	Olig	S	Por	5,272	5,286	12			
212		42	Wilcox (Rockdale)	Eoc	S	25	4,822	4,867	15	AF	Lower Cretaceous	11,042
		42.8	Wilcox (Rockdale)	Eoc	S	Por	5,096	5,176	20			
		40.5	Wilcox (Rockdale)	Eoc	S	22.5	5,413	5,430	15			
		40.3	Wilcox (Rockdale)	Eoc	S	Por	5,513	5,578	20			
213		Gas	Cole	Eoc	S	Por	370	382	12	NL	Yegua	1,654
214		51	Frio	Olig	S	Por	8,634	9,005	15	A	Vicksburg	9,182
215		Gas	Lagarto-Oakville	Mio	S	Por	1,900	2,800	10	AF	Frio	7,211
		24.8	Heterostegina	Olig	S	Por	4,880	4,961	10			
		29.8	Frio	Olig	S	Por	5,672	5,676	4			
216		Gas	Oakville	Mio	S	Por	2,495	2,505	10	AF	Frio	8,483
		Gas	Catahoula	Olig	S	Por	3,960	4,100	10			
		26.8	Heterostegina	Olig	S	Por	4,930	4,952	20			
		38.7	Frio	Olig	S	Por	5,630	5,680	30			
		59.4	Frio	Olig	S	Por	5,730	5,775	15			
		40.4	Frio	Olig	S	Por	5,850	5,862	12			
217		30	Frio	Olig	S	Por	7,620	7,678	15	A	Frio	9,003
		30–31.5	Frio	Olig	S	Por	7,847	7,912	20			
		30.4	Frio	Olig	S	Por	7,925	7,970	25			
218		Gas	Frio	Olig	S	Por	963	975	12	A	Jackson	3,360
219		Gas	Jackson	Eoc	S	Por	348	370	22	ML	Cook Mt.	2,003
220		Gas	Mirando	Eoc	S	Por	2,708	2,730	15	MF	Cockfield	3,008
221		43.3	Frio	Olig	S	Por	4,193	4,259	10	MF	Jackson	4,889
222		48.1	Frio	Olig	S	Por	4,610	4,620	10	A	Jackson	6,006
		56	Vicksburg	Olig	S	Por	5,234	5,246	12			
223		24	Frio	Olig	S	Por	1,328	1,339	5	MF[34]	Yegua	2,757
224												

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[34] Data on type structure of some 1942 discoveries obtained through courtesy of Mr. P. W. McFarland, Sun Oil Co., Dallas, Texas.

TABLE 2.—*Summary of Drilling Operations in South Texas*

Important Wildcats Drilled in 1942

	District and County	Well Name and Location	Total Depth, Ft.	Surface Formation	Deepest Horizon Tested
	LAREDO DISTRICT				
1	Duval	R. Lopez No. 1 Sec. 455 (East Cole)	1,705	Goliad	Cole
2	Duval	Driscoll No. 80-A (Conoco-Driscoll)	3,701	Goliad	Jackson
3	Duval	D.C.R.C. No. 13 (Piedre Lumbre)	10,931	Catahoula	Midway
4	Jim Hogg	East No. B-1 (Colorado)	3,052	Catahoula	Cockfield
5	Starr	Garza No. 7 (North Sun)	4,586	Goliad	Frio
6	Starr	Garcia No. D-1 (Rincon)	4,105	Goliad	Frio
7	Starr	T. R. Slick No. D-1 (Rincon)	y	Goliad	Frio
8	Starr	S. A. Loan & Trust No. 1 (Rincon)	3,791	Goliad	Frio
9	Starr	Frost Natl. No. 2-B (Garcia)	3,754	Goliad	Frio
10	Webb	Houston No. 1 (Carolina-Texas)	9,224	Goliad	Midway
11	Zapata	Flores No. 1 Porcion 36	5,795	Mt. Selman	Cretaceous
	SOUTH CORPUS CHRISTI DISTRICT				
12	Brooks	S. Unit No. 2 (La Gloria)	6,950	Lissie	Frio
13	Jim Wells	Fee No. 1-4 (Henshaw)	5,850	Lissie	Vicksburg
14	Jim Wells	Seeligson No. 29 (Seeligson)	7,013	Lissie	Frio
15	Jim Wells	Stratman No. 1 (Quinto Creek)	5,790	Lissie	Jackson
16	Jim Wells	Koehn No. 2, Tract 2 (Orange Grove)	5,111	Lissie	Frio
17	Jim Wells	King-Arroyo No. 2 (Stratton)	7,281	Beaumont	Vicksburg
18	Kleburg	King-Paso Ancho No. 13 (Stratton)	6,650	Beaumont	Frio
19	Nueces	Pfluger No. 1 (Aqua Dulce)	7,107	Beaumont	Frio
20	San Patricio	Reed No. 1 (Midway)	6,555	Beaumont	Frio

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1942

	Drilled by	Initial Production per Day		Choke or Bean, Fractions of an Inch	Pressure, Lb. per Sq. In.		Remarks
		Oil, U. S. Bbl.	Gas, Millions Cu. Ft.		Casing	Tubing	
1	Henderson, Coquat	30			On Pump		Extension
2	Continental Oil Co.		44		1,200	1,050	North Extension
3	Magnolia Pet. Co.						Dry deep test
4	Sun Oil Co.	94					North extension
5	Sun Oil Co.	159		9/64	1,050	830	Northeast extension
6	Continental Oil Co.	233		1/4	800	550	Southwest extension
7	Continental Oil Co.	98					Southwest extension
8	Humble Oil & Rfg.	120		9/64	1,200	450	West extension
9	Sun Oil Co.	153		9/64	975	750	Extension
10	Transwestern & Continental						Deep Wilcox test, dry
11	Ralph E. Fair						Dry deep test
12	La Gloria Oper. Comm.	Distillate and gas					Southeast extension
13	Rand Morgan	20		11/64	575	375	1 mile south extension
14	Magnolia Pet. Co.	Distillate and gas		7/64	2,650	2,900	New 6400-ft. Frio sand
15	Kilgore Dev. Co.		Gas				West extension
16	Kilgore Dev. Co.	113		7/64	700	650	Southwest extension
17	Humble Oil & Rfg. Co.	127		3/16	Sealed	1,825	West extension
18	Humble Oil & Rfg. Co.	155		1/8	1,200	950	Southeast extension
19	Republic Nat. Gas	147		7/64	1,475	1,195	Extension
20	F. M. Boynkin	225		5/32	1,100	900	1 Mile West extension

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	34	15
Number of oil wells completed during 1942	434	13
Number of gas wells completed during 1942	21	5
Number of dry holes completed during 1942	143	186

TABLE 3.—*Wells Drilled in South Texas*, 1938–1942

FIELD WELLS

Year	Laredo District			South Corpus Christi District			South Texas
	Oil or Distillate	Gas	Dry	Oil or Distillate	Gas	Dry	Total
1938	682	44	143	459	32	75	1,435
1939	588	26	157	654	24	95	1,544
1940	593	45	160	477	18	52	1,345
1941	443	49	143	496	21	70	1,222
1942	180	12	88	267	14	55	616

RANK WILDCATS[a]

Year	Laredo District				South Corpus Christi District				South Texas	
	Oil	Distillate	Gas	Dry	Oil	Distillate	Gas	Dry	Total	Ratio, Discovery to Wildcats
1938	13	3	3	190	4	5	4	53	275	1/8.60
1939	12	2	0	189	10	5	0	68	286	1/9.86
1940	10	2	3	222	8	2	0	89	336	1/13.44
1941	8	1	4	172	3	1	0	58	247	1/14.50
1942	8	0	3	136	1	4	2	50	204	1/11.33

[a] Productive wildcats are included in field wells statistics.

TABLE 4.—*Total Number of Wells Drilled in South Texas Fields during* 1942

LAREDO DISTRICT

Field	Oil	Distillate and Gas	Gas	Dry	Total
DUVAL COUNTY					
Agua Prieta	0	0	0	1	1
East Benavides	0	1	0	0	1
Blanchard	0	0	0	1	1
Cadena	2	0	0	0	2
Casa Blanca	8	0	0	1	9
East Cole	3	0	0	1	4
Dinn	0	0	1	0	1
Conoco Driscoll	12	0	1	2	15
Garza	1	0	0	0	1
Gov't. Wells	3[a]	0	0	3	6
Hoffman	8	0	0	2	10
Keller	0	0	1	0	1
Kohler	2	0	1	1	4
Kreis	1	0	0	6	7
Peters	0	0	0	1	1
Piedra Lumbre	1	0	0	2	3
Rancho Solo	1	0	0	0	1
Rios	0	0	0	1	1
Sejita	1	2	0	3	6
Seven Sisters	3	0	0	3	6
Tarancahuas	0	0	0	2	2
Total Duval County	45	3	4	30	82
JIM HOGG COUNTY					
Chaparosa	2	0	0	1	3
Colorado	38	0	1	5	44
East	1	0	0	0	1
Holbein	0	0	0	1	1
Jones	0	0	0	1	1
Las Animas	1	0	0	0	1
Neuhaus	1	0	0	0	1
Randado	0	0	0	1	1
Total Jim Hogg County	43	0	1	9	53
MCMULLEN COUNTY					
South Campana	6	0	1	0	7
Green Branch	0	0	1	2	3
Total McMullen County	6	0	2	2	10
LASALLE COUNTY					
Washburn	7	0	0	3	10
Total LaSalle County	7	0	0	3	10
STARR COUNTY					
Boyle	1	0	0	0	1
Frost	1	0	0	0	1
Garcia	4	0	0	2	6
LaReforma	0	0	0	1	1
South LaReforma	0	0	0	1	1
Ricaby	0	0	0	1	1
Rincon	29	0	0	6	35
North Rincon	0	1	0	1	2
Sun	12	0	0	6	18
North Sun	7	0	0	3	10
Ulrich	1	0	0	3	4
Yturria	8	0	0	3	11
Yzaguirre	0	0	0	1	1
Total Starr County	63	1	0	28	92
WEBB COUNTY					
Adami	0	0	0	1	1
Aviator	0	0	0	2	2
Carolina-Texas	0	0	0	1	1
Glen	0	0	1	1	2
Killam	3	0	2	0	5
Laurel	0	0	0	1	1
Lykes	1	0	0	1	2
McLean	5	0	0	4	9
Mirando City	0	0	0	1	1
Total Webb County	9	0	3	12	24
ZAPATA COUNTY					
Escobas-Jennings	1	0	0	1	2
Glen	1	0	0	1	2
Lopena	0	0	2[a]	2	4
Total Zapata County	2	0	2	4	8
Grand total, Laredo district	176	4	12	88	280

[a] Includes one deepened well.

TABLE 4.—(*Continued*)

SOUTH CORPUS CHRISTI DISTRICT

Field	Oil	Distillate and Gas	Gas	Dry	Total
BROOKS COUNTY					
Alta Verde	0	0	0	1	1
Kelsey	1	0	0	0	1
LaGloria	0	2	0	1	3
Total Brooks County	1	2	0	2	5
HIDALGO COUNTY					
Alamo	0	2	0	0	2
LaReforma	0	0	0	1	1
McAllen	0	1	0	0	1
Nichols	3	0	0	1	4
Penitas	0	1	0	1	2
Total Hidalgo County	3	4	0	3	10
JIM WELLS COUNTY					
Agua Dulce	1	1	0	0	2
Alfred	0	0	0	1	1
Alice	0	1[a]	0	0	1
Armagosa	0	0	1	0	1
Ben Bolt	7[b]	4	0	7	18
Henshaw	1	0	0	0	1
Koopman	1	0	1	1	3
LaGloria	1	1	0	1	3
Orange Grove	7[a]	1	1	3	12
Premont	0	0	0	1	1
South Premont	0	1	0	0	1
Quinto Creek	2	0	1	1	4
Roth	0	0	1	0	1
Seeligson	51	1	1[a]	1	54
Stratton	2	3	0	1	6
Wade City	1	0	1	2	4
Total Jim Wells County	74	13	7	19	113
KLEBURG COUNTY					
Kingsville	1	0	0	1	2
Seeligson	4	0	0	1	5
Stratton	17	0	0	0	17
East Stratton	7	0	0	0	7
Total Kleburg County	29	0	0	2	31
NUECES COUNTY					
Agua Dulce	35	6	2[c]	8	51
Baldwin	0	0	0	2	2
Clara Driscoll	2	0	0	1	3
South Clara Driscoll	1	0	0	0	1
Flour Bluff	0	0	1	0	1
East Flour Bluff	1	0	1	0	2
London	0	0	0	1	1
Luby	1	0	0	0	1
North Luby	1	0	0	2	3
Minnie Bock	7	1	0	1	9
Petronilla	3	0	1	2	6
Richard King	7	0	0	1	8
Shield	1	0	0	0	1
Stratton	17	6	0	1	24
East Stratton	4	0	0	0	4
Total Nueces County	80	13	5	19	117
SAN PATRICIO COUNTY					
Midway	11	0	0	4	15
Odem	29	0	2	5	36
Plymouth	3	0	0	0	3
East Plymouth	0	0	0	1	1
Rooke	1	1	0	0	2
South Sinton	0	1	0	0	1
Total San Patricio County	44	2	2	10	58
WILLACY COUNTY					
Willamar	2	0	0	0	2
Total Willacy County	2	0	0	0	2
Grand total, South Corpus Christi district	233	34	14	55	336
Grand total, South Texas fields	409	38	26	143	616

[a] Includes one deepened well. [b] Includes two deepened wells. [c] Includes one gas-input well.

The reserve values of these new fields cannot now be estimated properly because of insufficient data concerning both their horizontal and vertical extents. Several, however, as shown in Table 4, already have been defined in certain directions (Green Branch, Garcia, Ulrich, Lykes, McLean, Penitas, Koopman, and Quinto Creek) by one or more dry holes, and indications are that the reserve values of 1942 discoveries may perhaps prove to be somewhat disappointing.

Fairly active drilling programs were carried on in some of the older fields in spite of acreage restrictions by the Government. The more active of these were: Agua Dulce, Ben Bolt, Colorado, Conoco Driscoll, Midway, Odem, Rincon, Seeligson, Stratton and Sun. Several received important extensions; Rincon, a big producer of high-octane crude, is worthy of mention in this connection. A few wildcats were drilled along the Wilcox trend, but of these only the gas-well discovery of the Green Branch field, McMullen County, provided new production.

Oil production for 1942 totaled 44,794,115 bbl., of which 39,234,738 bbl. were crude, and 5,559,377 bbl. were distillate produced at the wells, and condensate and other products obtained during recycling or repressuring operations. This shows, in

TABLE 5.—*Rank Wildcats (New Field Discoveries) Completed in South Texas during* 1942

County	Oil	Distillate and Gas	Gas	Dry Holes	Total
LAREDO DISTRICT					
Duval	2	0	2	39	43
Jim Hogg	1	0	0	12	13
LaSalle	0	0	0	8	8
McMullen	0	0	1	9	10
Starr	3	0	0	33	36
Webb	2	0	0	26	28
Zapata	0	0	0	9	9
Total	8	0	3	136	147
Average, one new field per 13.36 rank wildcats.					
SOUTH CORPUS CHRISTI DISTRICT					
Brooks	0	0	0	5[a]	5
Cameron	0	0	0	2	2
Hidalgo	0	2	0	10	12
Jim Wells	1	1	2	10	14
Kenedy	0	0	0	0	0
Kleburg	0	0	0	0	0
Nueces	0	0	0	12	12
San Patricio	0	1	0	9	10
Willacy	0	0	0	2	2
Total	1	4	2	50	57
Average, one new field per 8.1 rank wildcat					
Grand total, South Texas	9	4	5	186	204
Average South Texas, one new field per 11.33 rank wildcats.					

[a] Includes one deepened well.

comparison with the 1941 production of 50,511,866 bbl. of oil, a decline of 11.3 per cent. Gas production for 1942 was 328,208,837 million cubic feet; this compares with 323,201,341 million cubic feet produced in 1941, an increase of 1.53 per cent.

To illustrate the trends and results of drilling in South Texas over the past five years, a summary of all drilling operations is shown in Tables 3 to 7, inclusive.

TABLE 6.—*Texas Railroad Commission Production Schedule for* 1942[a]

Month	Number of Producing Days	Number of Shut-in Days
January	24	7
February	21	7
March	18	13
April	12	18
May	19	12
June	20	10
July	20	11
August	22	9
September	21	9
October	22	9
November	21	9
December	22	9
Total for 1942	242	123
Total for 1941	252	113
Total for 1940	295	71
Total for 1939	252	113

[a] Statewide schedule; does not take into consideration special orders relating to individual fields.

TABLE 7.—*New Field and Sand Discoveries*

District, *County*, Field	Company	Well	Survey	Sand		Initial Production, Bbl. or T.C.F. per Day	Choke In.	Gravity, Deg. A.P.I.	Total Depth, Ft.	Completion Date	Remarks
				Name	Depth, Ft.						
LAREDO DISTRICT											
Duval: Cadena	Taylor Ref.	Cadena No. 1	C. Rios-306	Pettus	5,269–5,275	76	¼	44.1	5,800	Aug. 26, 1942	Discovery
				Hockleyensis	4,550–4,558	Show oil					
Garza	Newman Bros. &	De La Garza									
	Highland Oil	No. 1	524	Mirando	3,301–3,312	25				Jan. 15, 1942	Discovery
Dinn	Republic Nat. Gas	J. T. Dinn No. 1	665	Upper Jackson	2,481–2,491	8,000 TCF			3,006	Sept. 1942	Discovery
Keller	P. L. Keller	W. R. Peters No. 1	162	Mirando	2,614–2,624	2,000 TCF			2,661		Discovery
				Cole	1,801–1,809	Gas odor					
				Hockleyensis	2,410–2,447	Show oil					
Govt. Wells	Sun Oil	Weiderkehr No. 77-A	55	Hockleyensis	1,818–1,825	123		20.8			New sand
Sejita	Trinity Gas	Garcia No. 1	32	Jackson	5,780–5,816	132	¼	44.0	5,930		New sand
Jim Hogg: East Field	Sun Oil	East No. 1	Santo Domingo	Cockfield	4,740–4,741	8	3⁄16	51.0	5,303	Oct. 13, 1943	Discovery
			De Arriba		3,998–4,003	Show gas					
McMullen: Green Branch	Quintana	S. Texas No. 1-C	25	Wilcox	5,720–5,726	6,000 TCF			7,623	July 1943	Discovery
S. Campana	Argo	Edrington No. 1-K	63	Cole	1,864–1,867	8,000 TCF			4,486		New sand
LaSalle: Washburn	Quintana	S. Texas No. 10	86	Wilcox	5,534–5,550	438	¼	42.1			
					5,130–5,176	5,000 TCF			5,552	Apr. 10, 1942	New sand
	Quintana	S. Texas No. 13	94		5,096–5,102	110	⅛	42.8	5,658	Aug. 20, 1942	
Starr: Frost	Sun Oil	Frost No. 2-A	96	Frio	4,184–4,191	45		45.1	5,435	May 24, 1942	Discovery
Garcia	Sun Oil	Garcia No. 1-A	97	Frio	3,740–3,755	196	5⁄32	43.8	4,075	Mar. 7, 1942	Discovery
Ulrich	Fidelity O. & R.	Sugarland No. 1		Frio	3,965–3,972	77	3⁄16	45.8	4,200	Aug. 1942	Discovery
N. Sun	Sun Oil	Olivares No. 2		Frio	4,547–4,555	124	9⁄64		4,555		New sands
Webb: McLean	O. W. Killam	M. McLean No. 1	610	Yegua	3,238–3,253	168	¼	54.1	4,016	Jan. 12, 1942	Discovery
Lykes	Magnolia Pet.	D.C.R.C. No. 1	League 4	Mirando	1,950–1,968	15		45(?)	2,638	June 24, 1942	Discovery
SOUTH CORPUS CHRISTI DISTRICT											
Hidalgo: Penitas	Arkansas Fuel	J. W. Heard No. 1	Lot 235	Frio	6,020–6,026	22	5⁄32	60.9	6,802	Jan. 19, 1942	Discovery
			Chaves Gr.			1,121 TCF					
Alamo	McCollum Oil	McSweeney No. 1	El Gate Grant	Frio	5,005–5,998	200	3⁄16	58.0	6,567	Apr. 11, 1942	Discovery
						30,000 TCF					
McAllen	W. R. Davis	Jackson-Harrison		Frio	7,042–7,570	18	Open	56.0			New sands
		No. 1				17,000 TCF					
Jim Wells: Koopman	Henshaw Bros.	Koopman No. 1	21	Frio	4,112–4,122	210	3⁄16	44.5	6,016	Feb. 26, 1942	Discovery
	Coastal Rfrs.	Wright No. 1		Frio	4,690–4,692	Gas			4,692		New sand
						1½		Distillate			
S. Premont	Shell Oil	Jones No. 1		Frio	6,040–6,067	1,200 TCF	3⁄32		7,631		Discovery
			126			12		Distillate			
Roth	Smith & Mosser	Roth No. 1	Geo. Reynolds	Frio	3,245–3,275	12,500 TCF	¼		5,405	Dec. 1942	Discovery
		Joint Stock									
Stratton	S. E. Wilson, Jr.	Land Bank No. 1-C	8		6,436–6,452	165	⅛	41.2	6,600		New sand
Alice	Southern Miner	Stillwell No. 2		Yegua	–7,767	120	5⁄32	49.5	7,767		New sand
Ben Bolt	H. H. Nowell	Whatley No. 2		Frio	4,503–4,513	321	3⁄16	34.0	5,671		New sand
Orange Grove	Smith & Mosser	Diersing No. 1	112	Frio	3,292–3,308	20,000 TCF			3,320		New sand
Quinto Creek	Plymouth	Kuck No. 1		Vicksburg	5,067–5,083	5,000 TCF	3⁄16		5,828	Mar. 7, 1942	Discovery
	H. R. Smith	Kowler No. 1		Frio	4,860–4,870	162	5⁄32	29.0	5,812		New sand
San Patricio: S. Sinton	T.W.A.	San Antonio	McAuley	Frio	6,663–6,682	4,550 TCF	¼		6,687		Discovery
		Loan & Trust No. 1				50		53.9			

Oil and Gas Development in South Central Texas for 1942

By William H. Spice, Jr.,* Member A.I.M.E.

The year 1942 in the South Central Texas area was marked by a sharp curtailment of exploratory drilling as compared with the past several years. In the 33 counties that compose this district, 17 of which are nonproducing counties, only 51 exploratory wells were drilled during the year 1942. This compares with 118 exploratory wells drilled during 1941, or a decrease of more than 50 per cent. At the end of the year 10 active exploratory wells were drilling in this area, as against 19 being drilled at the end of 1941.

Of the exploratory wells drilled, two brought in oil wells and were new field discoveries and one was a gas well extending a recently discovered shallow gas area in the western part of the district. This compares with five new oil fields, one new gas field and two extension wells drilled in 1941.

Both new field discoveries were small and in areas outside of the general trend of the main producing horizon of the district in Edwards limestone. One new field, the Imogene, in Atascosa County, is a deep Edwards limestone prospect at 7500 ft., and the other new field, the Poth, in Wilson County, is a shallow Wilcox (Eocene) prospect at 4000 ft. Subsequent drilling in each field to the end of 1942 has proved disappointing.

There were no new discoveries along the old Balcones fault-line trend, although 35 of the exploratory wells were drilled in counties along this trend. Approximately 38 wells were drilled in or adjacent to the proven fields of the district, of which 18 were oil wells, 2 were gas wells and 17 were dry holes.

The district produced 6,186,178 bbl. of oil during 1942, which was a 7 per cent decrease under production for 1941. Approximately 4,961,000 bbl. of this total production, a slight increase over 1941, was produced by the four Edwards-limestone fields, Luling, Branyon, Salt Flat and Darst Creek, and the rest of the production came from the other 42 active fields in the district. During the year, 20 new producing wells were completed and 221 wells were abandoned in the producing fields. This alarming excess rate of abandonments over completions will be further reflected undoubtedly by a further decreased rate of 1943 production under 1942. Two active fields in the district in which more than one producing well was completed during the year were Bee Creek and Washburn.

The majority of exploratory work in the district was confined to areas along the Wilcox trend, with a certain amount in progress along the deeper Edwards limestone trend. The successful completion of several wells in the Washburn field from multiple sands in the Lower Wilcox (Eocene) has stimulated exploratory work along this trend, while the completion of a small well in the Imogene field from the Edwards limestone at 7500 ft. has renewed interest in this horizon at depths greater than generally are producing in the district.

New Fields

Imogene Field, Atascosa County.—Humble Oil and Refining Company's No. 1

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TABLE 1.—*Oil and Gas Production in South Central Texas*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
										During 1942		End of 1942			Number of Wells	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift
1	Alta Vista,[1] *Bexar*	1912	300	0	125,480	1,383	0	0	41	0	20	0	21	0	0	21
2	Bee Creek, *Caldwell*	1940	310	0	249,057	89,953	0	0	32	6	1	0	31	0	0	31
3	Branyon, *Caldwell*	1930	900	0	2,966,758	218,726	0	0	185	0	0	0	167	0	0	167
4	Buchanan, *Caldwell*	1928	250	0	453,326	24,998	0	0	41	0	0	0	23	0	0	23
5	Burdette Wells (N. E. Luling), *Caldwell*	1936	200	0	59,727	1,306	0	0	12	0	0	0	2	0	0	2
6	Byersville,[2] *Williamson*	1933	370	0	567,309	19,541	0	0	41	0	0	0	41	0	0	41
7	Carrizo, *Dimmit*	1941	20	0	6,059	841	0	0	1	0	0	0	1	0	1	0
8	Carroll,[3] *Bastrop*	1932	100	0	101,547	0	0	0	9	0	7	0	0	0	0	0
9	Cedar Creek, *Bastrop*	1932	100	0	296,972	11,578	0	0	13	0	1	0	7	0	0	7
10	Chapman, *Williamson*	1928	450	0	4,411,493	57,477	0	0	70	0	0	0	70	0	0	70
11	Chicon Lake, *Medina*	1920	450	0	95,136	16,096	0	0	83	1	0	0	76	0	0	76
12	Chriesman,[4] *Burleson*	1938	10	0	19,310	0	0	0	1	0	0	0	0	0	0	0
13	Dale, *Caldwell*	1927	280	0	1,604,720	40,371	0	0	58	0	0	0	52	0	0	52
14	West	1932	240	0		13,474	0	0								
15	North (Bateman)	1941	320	0		2,856	0	0	12	0	0	3	1	0	0	1
16	South[3]	1937	10	0		0	0	0	1	0	1	0	0	0	0	0
17	Darst Creek, *Guadalupe*	1928	1,920	0	52,682,644	2,186,128	0	0	362	0	0	12	338	0	8	330
18	Darst Creek Extension (Clark), *Guadalupe*	1935	200	0	386,127	6,504	0	0	11	0	0	0	5	0	0	5
19	Day,[5] *Guadalupe*	1940	20	0	0	0	0	0	2	0	0	0	0	0	0	0
20	Dunlap, *Caldwell*	1930	120	0	368,446	12,990	0	0	14	0	1	0	6	0	0	6
21	Dunlay,[5] *Medina*	1938	30	0	1,988	0	0	0	1	0	0	0	0	0	0	0
22	Eckert, *Bexar*	1927	850	0	934,892	23,613	0	0	121	0	10	0	101	0	0	101
23	Elgin, *Bastrop*	1941	10	0	3,565	0	0	0	1	0	0	1	0	0	0	0
24	Elm Creek, (Lavernia), *Guadalupe*	1939	400	0	33,921	9,424	0	0	47	0	0	2	29	0	0	29
25	Floresville, *Wilson*	1941	5	0	0	0	0	0	1	0	0	1	0	0	0	0
26	Gas Ridge, *Bexar*	1912	150	0	101,942	18,171	*y*	*y*	128	0	0	0	63	*y*	0	63
27	Hilbig, *Bastrop*	1932	260	0	1,701,759	68,369	0	0	14	0	0	0	14	0	12	1
28	Imogene, *Atascosa*	1942	10	0	835	835	0	0	2	1	1	0	1	0	0	1
29	Jones, *Bexar*	1921	20	0	2,888	171	0	0	3	0	0	1	2	0	0	2
30	Kimbro, *Travis*	1935	40	0	4,174	455	0	0	4	0	0	0	4	0	0	4
31	La Coste (Fairfield), *Bexar*	1939	40	0	4,112	275	*y*	*y*	5	0	0	1	1	0	0	1
32	Larremore, *Caldwell*	1927	80	0	354,908	13,241	0	0	13	0	0	5	7	0	0	7
33	Lentz, *Bastrop*	1941	60	0	17,136	11,476	0	0	3	0	0	0	3	0	0	3
34	Lone Oak,[6] *Bexar*	1934	10	0	4,485	0	0	0	1	0	0	0	0	0	0	0
35	Luling, *Caldwell and Guadalupe*	1921	2,200	0	78,373,010	1,549,336	0	0	606	0	0	0	580	0	0	580
36	Lytton Springs, *Caldwell*	1925	1,360	0	8,675,463	90,520	0	0	157	0	0	0	146	0	0	146
37	Manda,[3] *Travis*	1935	40	0	25,269	0	0	0	3	0	0	0	0	0	0	0
38	Manford, *Guadalupe*	1929	40	0	415,312	7,162	0	0	1	0	0	0	1	0	0	1
39	Minerva-Rockdale, *Milam*	1921	4,250	0	3,744,519	66,830	0	0	423	0	0	0	419	0	0	419
40	Nash Creek,[4] *Guadalupe*	1936	10	0	46,535	0	0	0	1	0	0	0	0	0	0	0
41	Pearsall, *Frio*	1933	800	0	1,680,377	178,648	0	0	35	1	0	0	35	0	9	26
42	Philtop,[3] *Bexar*	1938	40	0	8,171	372	0	0	8	0	4	0	0	0	0	0
43	Poth, *Wilson*	1942	40	0	0	0	0	0	2	2	0	2	0	0	0	0
44	Riddle, *Bastrop*	1938	50	0	85,416	10,137	0	0	7	0	0	0	3	0	0	3
45	Salt Flat, *Caldwell*	1928	1,300	0	43,514,825	1,007,575	0	0	298	0	0	6	272	0	0	272

[b] Footnotes to column heads and explanation of symbols are given on page 264.

[1] Includes Dupree.

[2] Includes Mathews and Noack.

[3] Abandoned 1942.

[4] Abandoned 1941.

[5] Abandoned 1940.

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
										Top Prod. Zone	Bottoms Prod. Wells				
1	*x*	*y*		18°	*y*	Navarro sands	CreU	S	15–20	220	250	20	F	Trinity sand	4,535
2	*y*	*y*		39°	*y*	Dale lime, serpentine	CreU	LP	Por	2,050	2,240	*y*	Intn	Austin chalk	2,426
3	*x*	*y*		37°	0.8	Austin chalk, Edwards limestone	CreU & L	L	Por	1,816	2,275	*y*	F	Edwards limestone	2,450
4	*x*	*y*		39°	0.2	Serpentine	CreU	P	12	1,750	2,075	*y*	Intn	Edwards limestone	2,483
5	200	*y*		28°	0.8	Edwards limestone	CreL	L	Crev	2,210	2,235	15	F	Edwards limestone	2,420
6	*y*	*y*	RP	37°	0.2	Serpentine	CreU	P	20	850	900	*y*	Intn	Edwards limestone	2,000
7	*y*	*y*		30°	*y*	Navarro sand	CreU	S	26	2,294	2,298	4	MC	Taylor marl	3,120
8	*y*	*y*		36°	*y*	Serpentine	CreU	P	12	2,300	2,378	78	Intn	Edwards limestone	2,919
9	100	*y*		35°	0.2	Serpentine	CreU	P	15–20	1,650	1,700	50	Intn	Edwards limestone	2,300
10	400	*y*		36°	0.2	Serpentine	CreU	P	20	1,750	1,915	20	Intn	Edwards limestone	3,226
11	*x*	*y*		21°	0.1	Navarro sands	CreU	S	15	260	750	20	D	Edwards limestone	1,725
12	*y*	*y*		34.5°	*y*	Edwards lime	CreL	L	Por	6,167	6,182	*y*	F	Edwards limestone	6,340
13 14 15	150	*y*		37°	0.2	Dale lime, serpentine	CreU	LP	15	1,915	2,250	30	Intn	Edwards limestone	2,661
16	*y*	*y*		*y*	*y*	Dale lime, Austin chalk	CreU	LC	Por	2,018	2,420	*y*	F	Austin chalk	2,420
17	350	*y*		36°	0.8	Edwards lime	CreL	L	Por	2,650	2,700	30	F	Travis Peak	5,509
18	200	*y*		33.6°	0.5	Austin chalk	CreU	C	5–25	2,375	2,450	100	F	Edwards limestone	3,200
19	*y*	*y*		36°	*y*	Austin chalk, Buda lime	CreU & L	CL	Por	2,337	2,685	*y*	F	Edwards limestone	2,830
20	400	*y*		36°	0.6	Austin chalk	CreU	C	Crev	2,300	2,375	15	F	Edwards limestone	2,420
21	*y*	*y*		21°	*y*	Serpentine	CreU	P	*y*	542	714	*y*	Intn	Austin chalk	851
22	*y*	*y*		34°	0.3	Navarro sands	CreU	S	16	620	790	10	F	Edwards limestone	1,590
23	*y*	*y*		36°	*y*	Austin chalk	CreU	C	Crev	2,820	2,840	20	F	Edwards limestone	3,352
24	*y*	*y*		41°	*y*	Navarro sands	CreU	SH	Por	700	850	*y*	T	Navarro	846
25	*y*	*y*		*y*	*y*	Reklaw sand	Eoc	S	*y*	635	640	*y*	*y*	Reklaw	662
26	*x*	*y*		22°	0.4	Navarro sands	CreU	S	15–20	230	760	15	A	Travis Peak	3,460
27	1,240	*y*	PM	37°	0.2	Serpentine	CreU	P	12	2,450	2,575	50	Intn	Edwards limestone	3,250
28	*y*	*y*		38.7°	*y*	Edwards limestone	CreL	L	Por	7,570	7,572	2	*y*	Edwards limestone	7,648
29	*x*	*y*		*y*	*y*	Navarro sands	CreU	SH	Por	600	*x*	*x*	T	Edwards limestone	2,008
30	*x*	*y*		36.5°	*y*	Serpentine	CreU	P	Por	660	670	*y*	Intn	Edwards limestone	1,280
31	*x*	*y*		28°	*y*	Anacacho limestone	CreU	L	Por	1,150	1,190	*y*	N	Austin chalk	1,227
32	*x*	*y*		23°	0.6	Edwards limestone	CreL	L	30	1,285	1,315	35	F	Travis Peak	3,360
33	*y*	*y*		36°	*y*	Dale limestone	CreU	L	Por	2,226	2,244	18	F	Austin chalk	2,453
34	*x*	*x*		33.4°	*y*	Navarro-Taylor	CreU	SH	Por	1,480	1,620	18	F	Edwards limestone	2,250
35	1,500	*y*		27°	0.9	Edwards limestone	CreL	L	25	2,100	2,200	50	F	Schist	7,859
36	1,250	*y*		37.5°	0.4	Serpentine	CreU	P	12	1,535	1,820	300*x*	Intn	Edwards limestone	2,050
37	*x*	*y*		34°	0.4	Serpentine	CreU	P	15–25	720	757	*x*	Intn	Taylor marl	850
38	1,250	*y*		37°	0.9	Austin chalk	CreU	C	Crev	2,260	2,310	30	F	Edwards limestone	2,800
39	*x*	*y*		38°	0.2	Navarro sands	CreU	SH	Por	600	1,700	15	T	Glenrose	5,000
40	340	*y*		27°	0.8	Taylor marl	CreU	SL	Por	2,570	2,585	15	F	Edwards limestone	3,342
41	1,500	*y*		27° 38°	*y* *y*	Navarro sand Austin chalk	CreU CreU	S C	Por Por	3,920 5,400	3,950 5,850	15 *x*	N N	Travis Peak	10,050
42	*x*	*y*		23°	*y*	Austin chalk	CreU	C	Por	1,100	*y*	*y*	F	*y*	*y*
43	*y*	*y*		26.8°	*y*	Wilcox and Midway sands	Eoc	S	Por	4,082 4,252	4,100 4,266	*y*	F	Midway	4,410
44	*x*	*y*		39°	*y*	Austin chalk, serpentine	CreU	CP	Por	1,667	1,747	*y*	F	Austin chalk	1,777
45	1,200	*y*		36°	0.6	Edwards lime	CreL	L	30	2,670	2,740	25	F	Edwards limestone	2,918

M. L. Thompson discovery well of the Imogene field was completed on Nov. 5, 1942, from Edwards limestone at 7570 to 7572 ft., pumping 38 bbl. of 38°A.P.I. gravity oil per day with 70 per cent sulphur water, after being plugged back from a total depth of 7576 ft. This well is about 3 miles northeast of the Imogene townsite and 4 miles south of Pleasanton, on a large block of acreage acquired by the Humble as a result of extensive core-drill and geophysical work. A second well, Humble Oil and Refining Company's No. 1 Soechting, about 1800 ft. to the northeast, was drilled to a total depth of 7648 ft. It encountered the top of the Edwards limestone slightly higher than in the discovery well but was abandoned after several tests in the Edwards failed to show commercial production. As of the end of the year, a third well, No. 1 Duren and Richter, about ¾ mile west of the discovery, was being drilled. The particular significance of this discovery is the establishment of commercial production in the Edwards limestone in this district at levels considerably deeper than have heretofore produced.

Poth Field, Wilson County.—Holland Oil Company's (later Superior Oil Co.) No. 1 Chas. Boysen discovery well of the Poth field was completed on June 10, 1942, from basal Wilcox (Eocene) sand at 4090 to 4096 ft., pumping 31 bbl. of 26.8°A.P.I. gravity oil per day with 50

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942	
										During 1942		End of 1942			Number of Wells	
			Oil	Gas[b]	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[e]	Producing Gas[c]	Flowing	Artificial Lift
46	Somerset, *Atascosa and Bexar*	1912	11,390	0	11,064,058	140,937	0	0	915	0	168	0	706	0	0	706
47	Southton-Yturria, *Bexar*.....	1921	650	0	687,645	14,690	0	0	103	0	0	0	103	0	0	103
48	Spiller, *Guadalupe*...........	1938	30	0	20,803	3,330	0	0	6	0	0	0	4	0	0	4
49	Taylor-Ina, *Medina*..........	1922	380	0	159,515	3,789	0	0	17	1	0	0	9	0	0	9
50	Tenney Creek, *Caldwell*......	1940	150	0	209,557	113,286	0	0	24	0	0	0	24	0	1	23
51	Thrall, *Williamson*..........	1914	475	0	2,499,776	17,480	0	0	27	0	0	1	20	0	0	20
52	Von Ormy, *Bexar*...........	1933	650	0	292,300	25,647	0	0	108	0	0	6	102	0	0	102
53	Walnut Creek, *Caldwell*......	1938	50	0	8,003	831	0	0	3	0	0	0	1	0	0	1
54	Washburn, *LaSalle*..........	1940	200	640	103,420	77,559	y	y	15	7	5	0	10	1[6]	8	2
55	Yost, *Bastrop*................	1928	120	0	922,007	3,859	0	0	6	0	0	0	4	0	0	4
56	Zoboroski, *Guadalupe*........	1935	180	0	244,866	15,641	0	0	14	0	0	0	14	0	0	14
	GAS ONLY															
57	Adams (Medina), *Medina*....	1926	0	2,000	0	0	y	y	58	0	0	0	0	13	0	0
58	Chittim, *Maverick*...........	1929	0	100[7]	70,342	8,297	y	y	20	0	1	0	0	5	0	0
59	Pendencia Creek, *Dimmit*....	1941	0	1,320y	0	0	y	y	3	1	1	0	0	2	0	0
60	Total..................		32,940	4,060	220,411,905	6,186,178			4,149	20	221	41	3,519	21	39	3,479

[6] Dual completion.
[7] Gas and distillate.

per cent salt water, after drilling into the Midway formation to a total depth of 4410 ft. This well is about 5 miles northeast of the town of Poth, on a prospect determined by surface geology, core drilling and geophysical work. A second well, Superior Oil Corp. and Progress Petroleum Company's No. 1 Gus J. Gross, about ½ mile southwest of the discovery well, was drilled to a total depth of 4314 ft., and after considerable mechanical difficulty pumped oil and water from a new sand in the Midway at 4262 to 4276 ft. No further development was carried on during the remainder of the year and both wells were shut down temporarily. This discovery indicates the possibilities of commercial production from lower Wilcox and upper Midway sands at comparatively shallow depths throughout the district and may lead to a new exploratory trend.

EXTENSIONS

Pendencia Creek, Dimmit County.—Wellington Oil Company's No. 2-B D. J. Sullivan, 2 miles south of the discovery well in the Pendencia Creek gas field, was completed as a small gas well making 800,000 cu. ft. from sand in the Navarro (Upper Cretaceous) at 1885 to 1893 ft. after drilling to a total depth of 2824 ft. This is the second gas horizon developed in the Navarro section in this field and

TABLE 1.—(*Continued*)

Line Number	Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Initial	Avg. at End of 1942		Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
46	300	*y*		36°	1.4	Navarro and Taylor sands	CreU	SH	22	1,200	2,100	30	TF	Travis Peak	5,311
47	*x*	*y*		32°	*y*	Navarro sands	CreU	S	16	600	800	10	F	Glen Rose	3,850
48	*x*	*y*		38.3°	*y*	Buda limestone	CreL	L	Por	2,012	2,298	*y*	F	Edwards limestone	2,382
49	*x*	*y*		18°	0.5	Navarro sands	CreU	S	15–20	290 940	400 960	15 10	FT	Edwards limestone	2,048
50	*x*	*y*		35.5°	*y*	Austin chalk, Buda limestone	CreU & L	CL	Por	2,340	2,703	60	F	Buda limestone	2,703
51	400	*y*		37°	0.3	Serpentine	CreU	P	25	700	1,000	75	Intn	Travis Peak	3,290
52	*x*	*y*		34°	0.4	Navarro sands	CreU	SH	10	506	730	20	F	Edwards limestone	2,835
53	*x*	*y*		36°	*y*	Serpentine	CreU	P	Por	1,230	1,336	*y*	Intn	Edwards limestone	2,600
54	*y*	*y*		41°	*y*	Wilcox sands	Eoc	S	20–25	4,822 5,094 5,527	4,832 5,102 5,566	*y*	F	Edwards limestone	11,042
55	400	*y*		27°	0.3	Serpentine	CreU	P	15–25	1,335	1,500	100	Intn	Edwards limestone	2,600
56	150	*y*		30.4°	0.8	Austin chalk	CreU	C	10	2,050	2,200	75	F	Edwards limestone	2,600
						GAS ONLY									
57	*x*	*y*		0	0	Navarro & Taylor sands	CreU	SH	Por	900	*y*	*y*	F	Edwards limestone	2,289
58	*x*	*y*		42–44°	*y*	Buda, Edwards, Glen Rose	CreL	L	Por	3,205 3,255 5,650	*y*	*y*	A	Travis Peak	7,635
59	*y*	*y*		0	0	Navarro sand	CreU	S	Por	1,084 1,885	1,090 1,893	*y* *y*	A	Taylor	3,005
60															

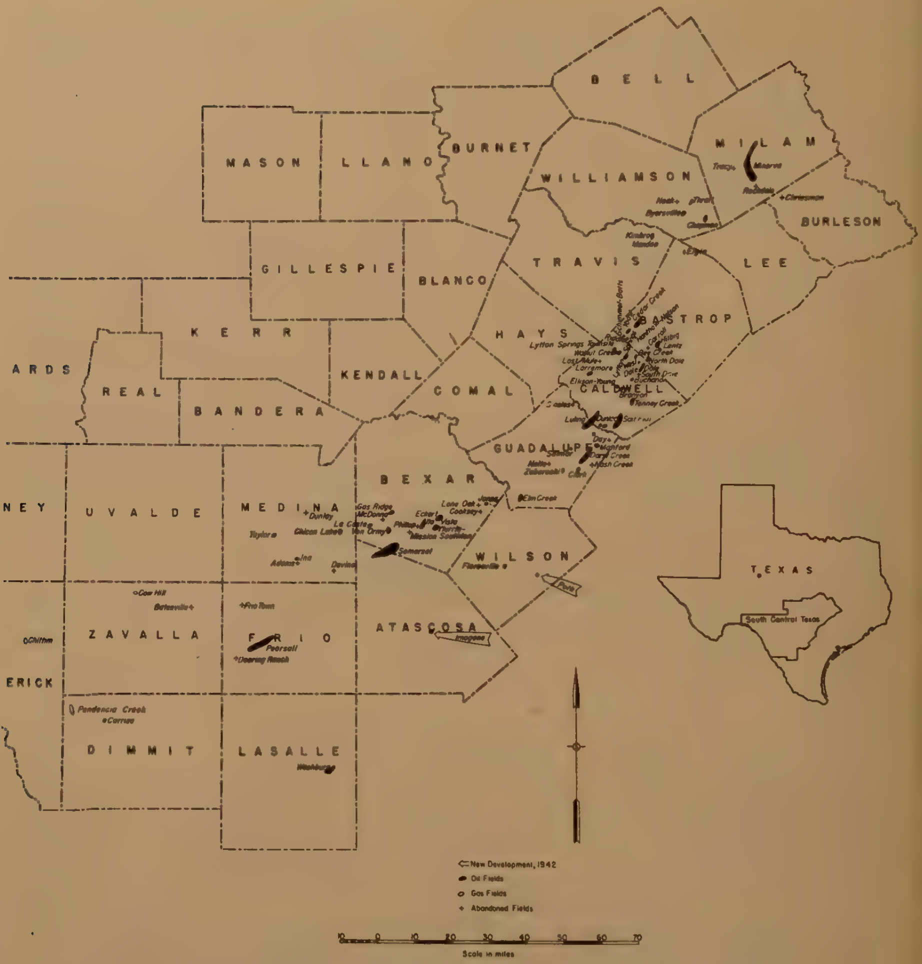

FIG. 1.—LOCATION OF OIL AND GAS FIELDS, SOUTH CENTRAL TEXAS.

was discovered as the result of surface geology. A third well was drilled in the area, Wellington Oil Company's No. 3-B D. J. Sullivan, about ¾ mile northwest of No. 2-B, and after showing gas in the upper Navarro sands was abandoned at a total depth of 1966 feet.

ACKNOWLEDGMENT

Appreciation and thanks are expressed to the various companies and individuals for their assistance and cooperation in furnishing many of the data on the various fields.

Developments in West Texas during 1942

By Robert S. Dewey,* Member A.I.M.E.

Drilling in West Texas during 1942 was substantially less than in the previous year. In all, 1267 wells were drilled, as compared with 2325 wells in 1941. Of these 1267 wells, 1052 oil wells, 10 gas wells and 69 dry holes were drilled in proven fields and 36 oil wells, one gas well and 99 dry holes were wildcat operations. Of the 36 wildcat wells completed as oil producers, 16 led to new field discoveries, three found new productive horizons in old fields, and 17 extended the productive limits of established fields.

Where semiwildcat drilling took place along established productive trends, there was often no sharp demarcation between wildcat wells that extend field limits and normal development to fulfil lease obligations, other than the arbitrary classification of a well as a wildcat if it was drilled at a distance of 2 miles from a producing oil well. The dry hole drilled on the edge of a field may have proved a more hazardous operation than a semiwildcat drilled several miles from production but favorably located on structure. The percentage of successful wildcatting ranges from 26.5 down to 14 per cent, dependent upon the degree of inclusion of the semiwildcat operations. Irrespective of which figure was used, the West Texas area maintained its better than average exploratory position.

No doubt a number of factors may have influenced the extent of the 1942 development. Among those arising from the economic dislocation attendant on the war effort, the following are worthy of note. Owing to inductions into the armed forces and shipyard competition for mechanically trained men, experienced drilling personnel was sharply reduced, thereby increasing drilling costs and well-completion hazards. Replacement labor has not met the same standard of responsibility or workmanship to which the oil industry has grown accustomed.

Increased military consumption of aviation gasoline and other crude products, coupled with decreased domestic consumption of lower-octane gasoline, has stimulated the market demand for the types of sweet crude most readily processed with available refinery equipment to meet war requirements, and has depressed the market demand for the sour West Texas crudes. As a majority of the purchasers of West Texas crude normally ship a substantial portion of sour crude to the refineries on the Atlantic seaboard, the loss and diversion of tanker service between Gulf Coast and north Atlantic ports have further curtailed the market demand for this type of crude oil. As some purchasers of crude oil were able to move by pipe line their West Texas trunk-line capacity to Midwestern refining centers, they were not impelled to curtail purchases of West Texas crude.

The varying ability of the purchasers of crude oil to market West Texas crude was reflected back to various fields to which they were connected, causing an unequal distribution of production as among fields and operators. The pipe-line runs from the West Texas-New Mexico area decreased from approximately 354,000 bbl. per day in January to about 265,000 bbl. in December 1942. Approximately 2,991,000 bbl. of West

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TABLE 1.—*Oil and Gas Production in West Texas*

Line Number	*County,* Field	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
1	*Andrews:* Deep Rock	1931	500	0	730,203	29,319
2	Embar	1942	1,400	0	101,454	101,454
3	Embar Permian	1942	1,000	0	14,040	14,040
4	Emma	1937	1,500	0	1,231,991	285,472
5	Fuhrman	1931	1,640	160	3,239,494	250,401
6	Fullerton	1942	960	0	112,731	112,731
7	Mascho	1942	560	0	7,072	7,072
8	Means	1934	7,600	160	6,048,700	706,576
9	Parker	1934	160	0	89,705	9,799
10	West Andrews	1940	1,000	0	68,226	45,394
11	West Fuhrman	1941	720	0	45,704	39,913
12	*Cochran:* Dean	1937	360	0	91,877	17,796
13	Rhodes	1941	40	0	4,516	2,632
14	*Cochran, Hockley and Terry:* Slaughter	1937	60,000	0	14,679,939	7,679,588
15	*Coke:* Blackwell	1942	40	0	3,303	3,303
16	*Concho:* Dodson	1941	20	0	1,108	684
17	*Crane:* Dune	1938	2,200	0	563,191	112,029
18	Edwards	1935	120	0	20,273	3,087
19	Ella Waddell	1940	640	0	49,520	27,770
20	McKee	1942	40	0	8,406	8,406
21	Sand Hills Ordovician {Simpson Ellenburger}	1936	1,280	0	1,026,809	427,017
22	Sand Hills Permian	1930	7,000	160	3,752,204	727,099
23	Waddell	1927	3,500	0	4,116,771	490,954
24	*Crane and Ector:* Jordan	1937	5,620	0	5,838,282	1,348,019
25	*Crane and Upton:* Crane-Cowden	1926	2,880	0	5,401,602	190,272
26	McElroy	1926	14,000	0	126,907,182	4,908,919
27	*Crockett:* Bean	1941	40	0	4,109	294
28	Clara Couch	1941	280	40	11,938	10,952
29	Crockett	1938	1,020	0	359,915	87,908
30	Hoover	1941	80	0	6,294	4,455
31	Live Oak	1940	40	0	2,720	1,108
32	Noelke	1940	1,000	1,000	190,589	83,072
33	Olson	1940	160	0	10,480	5,843
34	Simpson	1938	160	0	5,416	938
35	*Crockett:* Todd Deep	1940	1,000	0	201,281	68,304
36	World	1926	2,380	0	7,732,524	608,753
37	Wyatt	1940	40	0	34,942	5,026
38	*Dawson:* Welch	1941	160	0	9,711	9,516
39	*Ector:* Foster	1935	12,800	0	15,477,181	2,266,778
40	Goldsmith	1934	20,000	x	39,237,954	6,503,484
41	Harper	1933	4,500	0	7,972,427	620,337
42	Johnson	1935	7,520	0	1,861,596	686,853
43	North Cowden	1930	21,500	0	23,882,059	2,989,527
44	North Cowden Deep	1939	200	0	118,647	28,242
45	North Goldsmith	1936	640	160	103,349	33,700
46	Penwell	1930	6,200	x	23,249,302	847,697
47	South Cowden	1933	4,290	x	2,787,296	596,840
48	*Gaines:* Cedar Lake	1939	2,500	0	576,148	319,988
49	Robertson	1942	160	0	2,785	2,785
50	Seminole	1937	12,500	0	5,357,446	1,430,618
51	Wasson Deep	1940	160	0	35,769	14,747
52	Wasson "72"	1941	160	0	34,896	33,819
53	*Gaines and Yoakum:* Wasson	1936	55,000	0	42,560,962	9,510,913
54	*Garza:* Garza	1935	80	0	121,976	6,731
55	*Glasscock:* Carter	1936	80		31,085	1,937
56	*Glasscock and Howard:* Howard Glasscock	1927	21,700	0	104,280,309	4,813,575
57	1400-foot pay	1927	1,700	0		
58	1800-foot pay	1926	4,000	0		
59	2200-foot pay	1929	8,000	0		
60	2500-foot pay	1928	2,000	0		
61	3000-foot pay	1928	6,000	0		
62	*Howard:* Iatan-East Howard	1926	7,000	0	16,389,658	1,450,102

[b] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operations[d]
				During 1942		End of 1942			Number of Wells				
	To End of 1942	During 1942[1]	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942	
1	*x*	*y*	10	0	0	0	10	0	2	8	1,800	*y*	
2	55.8	55.8	5	5	0	0	5	0	5	0	3.271	3,264	
3	11.2	11.2	7	7	0	0	7	0	7	0	2,341	2,341	
4	*x*	193.6	67	17	0	0	67	0	16	51	1,500	*y*	
5	*x*	817.7	55	1	0	0	54	1	38	16	1,800	*y*	
6	*y*	*y*	12	12	0	0	12	0	11	1	2,741	*y*	
7	*y*	*y*	7	7	0	0	7	0	1	6	*y*	*y*	
8	6,693.2	473.3	125	1	0	0	123	2	52	71	1,900	1,512	
9	*x*	*y*	2	0	0	0	2	0	0	2	*x*	*y*	
10	*y*	91.9	22	15	0	0	22	0	7	15	*x*	*y*	
11	*y*	*y*	14	13	0	0	14	0	7	7	*x*	*y*	
12	110.8	17.0	4	2	0	0	4	0	2	2	*x*	*x*	
13	*y*	*y*	1	0	0	0	1	0	1	0	*x*	*x*	
14	9,003.2	4,713.5	1,222	368	1	0	1,220	0	1,152	68	1,700	1,570	
15	*y*	*y*	1	1	0	0	1	0	0	1	*x*	*x*	
16	*x*	*x*	1	0	0	0	1	0	0	1	*x*	*x*	
17	*x*	48.0	27	0	0	1	26	0	11	15	*x*	*x*	
18	*x*	*x*	1	0	0	0	1	0	0	1	*x*	*x*	
19	*x*	*x*	5	1	0	0	5	0	1	4	*x*	*x*	
20	*y*	*y*	1	1	0	0	1	0	1	0	*x*	*x*	
21	*x*	540.6	32	4	0	0	32	0	30	2	*x*	*x*	
22	5,341.7	1,062.1	147	20	0	0	146	1	125	21	2,125	1,494	
23	*x*	352.5	84	5	0	0	84	0	74	10	*x*	*x*	
24	*x*	860.0	225	5	0	0	225	0	176	49	1,570	1,059	
25	*x*	*x*	115	0	0	1	100	0	0	100	*x*	*x*	
26	*x*	3,789.4	595	0	0	0	595	0	108	487	*x*	*x*	
27	*x*	*x*	1	0	0	1	0	0	0	0	*x*	*x*	
28	*x*	*x*	8	6	0	0	7	1	2	5	*x*	*x*	
29	*x*	*x*	37	1	0	0	37	0	4	33	*x*	*x*	
30	*x*	*x*	2	0	0	0	2	0	0	2	*x*	*x*	
31	*x*	*x*	1	0	0	0	1	0	0	1	*x*	*x*	
32	*x*	*x*	42	9	0	0	34	8	33	1	*x*	*x*	
33	*x*	*x*	2	1	0	0	2	0	0	2	*x*	*x*	
34	*x*	*x*	1	0	0	0	1	0	0	1	*x*	*x*	
35	*x*	*x*	14	1	0	0	14	0	14	0	2,670	2,566	
36	*x*	*x*	100	13	0	0	78	0	0	78	*x*	*x*	
37	*x*	*x*	2	0	0	0	1	0	1	0	*x*	*x*	
38	*x*	*x*	1	0	0	0	1	0	0	1	*x*	*x*	
39	*x*	1,085.8	575	13	0	0	575	0	300	275	1,740	1,097	
40	83,000	12,000.0	979	15	0	1	972	7	914	58	1,675	1,326	
41	*x*	1,184.8	184	0	0	0	184	0	23	161	*x*	*x*	
42	*x*	985.0	125	9	0	0	125	0	80	45	*x*	1,288	
43	*x*	2,890.9	535	29	0	0	535	0	435	100	1,740	1,241	
44	*x*	9.4	5	0	0	0	5	0	3	2	*x*	*x*	
45	1,080.4	121.4	11	0	0	0	10	1	2	8	*x*	826	
46	29,158.7	1,699.4	175	0	0	0	173	0	81	92	1,400	810	
47	*x*	325.9	116	5	0	0	116	0	87	29	1,740	1,189	
48	95.2	51.2	51	18	0	0	51	0	1	50	1,876	1,640	
49	*x*	*x*	1	1	0	0	1	0	1	0	*x*	*x*	
50	4,640.5	1,051.5	292	8	0	0	292	0	288	4	2,000	1,925	
51	20.5	6.8	1	0	0	0	1	0	1	0	*y*	2,128	
52	15.9	15.6	1	0	0	0	1	0	1	0	*y*	2,526	
53	44,919.3	9,445.6	1,402	148	2	0	1,399	0	1,316	83	1,800	1,650	
54	*x*	*x*	7	0	0	0	5	0	0	5	*x*	*x*	
55	*x*	*x*	2	0	0	1	0	0	0	0	*x*	*x*	
56	*x*	*x*	999	0	4	0	820	0	0	820	*x*	*x*	
57	*x*	*x*	107	0	0	0	106	0	0	106	*x*	*x*	
58	*x*	*x*	268	0	4	0	205	0	0	205	*x*	*x*	
59	*x*	*x*	125	0	0	0	78	0	0	78	*x*	*x*	
60	*x*	*x*	285	0	0	0	234	0	0	234	*x*	*x*	
61	*x*	*x*	214	0	0	0	197	0	0	197	*x*	*x*	
62	*x*	*x*	313	20	0	0	313	0	4	309	*x*	*x*	

[1] Gas volumes estimated from semiannual gas-oil ratio reports.

TABLE 1.—(*Continued*)

Line Number	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
							Depth, Avg. Ft.					
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
1	28	y	San Andres	Per	D	Por	4,288	4,476	y	A	San Andres	4,765
2	43	y	Ellenburger	Ord	D	Frac. Por	7,835	7,884	y	A	Ellenburger	8,425
3	43	y	Clear Fork	Per	D	Por	6,225	6,325	y	A	Ellenburger	8,425
4	34.6	y	San Andres	Per	D	Por	4,190	4,275	25	A	San Andres	4,500
5	28	4.7	San Andres	Per	D	Por	4,248	4,465	y	A	San Andres	4,614
6	y	y	Clear Fork	Per	D	Por	6,280	7,274	y	A	Wolf Camp	8,005
7	y	y	San Andres	Per	D	Por	4,446	4,540	y	A	Clear Fork	7,626
8	30	0.6	San Andres	Per	D	Por	4,475	4,535	25	A	San Andres	5,227
9	29.5	y	San Andres	Per	D	Por	4,627	4,790	7	MC	San Andres	4,814
10	36	y	San Andres	Per	D	Por	4,300	4,400	25	A	Ellenburger	8,368
11	y	y	San Andres	Per	D	Por	4,038	4,610	y	A	San Andres	5,600
12	30	y	San Andres	Per	D	Por	4,900	5,010	12	y	Clear Fork	6,621
13	31	y	San Andres	Per	D	Por	5,050	5,111	y	x	San Andres	5,150
14	32	1.9	San Andres	Per	D	Por	4,950	5,050	32	MC	Clear Fork	7,000
15	y	y	Cisco	Pen	L	Por	3,821	3,828	7	?	Cisco	3,828
16	y	y	y	y	y	y	y	y	y	y	y	y
17	36	y	Grayburg	Per	DL	Por	3,150	3,270	15	A	San Andres	3,795
18	y	y	Grayburg	Per	D	Por	3,315	3,661	y	A	San Andres	3,695
19	35	y	Grayburg	Per	D	Por	3,250	3,400	20	A	San Andres	3,734
20	y	y	Simpson	Ord	S	Por	6,125	6,168	y	?	Simpson	6,168
21	{37.5	0	Simpson	Ord	S	Por	5,550	5,600	20	AF	Pre-Cambrian	7,158
	{44.7	0	Ellenburger	Ord	D	Cav	5,900	6,000	20	AF	Pre-Cambrian	7,158
22	35	y	Wichita	Per	D	Por	4,250	4,630	40	A	Pre-Cambrian	7,158
23	y	y	Grayburg	Per	D	Por	3,444	3,520	y	A	Clear Fork	3,622
24	36	2.1	San Andres	Per	D	Por	3,500	3,650	20	A	San Andres	4,038
25	28	2.3	Grayburg	Per	DL	Por	2,250	2,300	30	A	Wichita	4,610
26	30	2.4	Grayburg	Per	D	Por	2,800	3,000	40	A	Ellenburger	12,786
27	26	y	San Andres	Per	D	Por	1,451	1,456	6	x	Ellenburger	7,010
28	26	y	San Andres	Per	D	Por	1,882	2,003	20	A	San Andres	2,166
29	31	1.7	Grayburg	Per	DS	Por	1,330	1,450	7	A	San Andres	1,635
30	26.8	y	Queen	Per	S	Por	1,425	1,450	10	N	San Andres	2,173
31	30	y	San Andres	Per	D	Por	2,012	2,145	10	x	San Andres	2,150
32	32	y	Seven Rivers	Per	S	Por	1,100	1,115	y	NC	San Andres	2,039
33	25	y	San Andres	Per	D	Por	2,202	2,250	15	A	San Andres	2,371
34	y	y	Grayburg	Per	D	Por	1,885	1,970	10	N	Grayburg	1,970
35	41.6	0	Crinoidal (Strawn)	Pen	L	Por	5,727	5,802	75	A	Ellenburger	7,010
36	29	0.6	Grayburg	Per	D	Por	2,415	2,550	13	A	San Andres	3,695
37	23	y	San Andres	Per	D	Por	1,525	1,530	5	A	Ellenburger	7,010
38	33	y	San Andres	Per	D	Por	4,918	4,986	y	A	San Andres	4,986
39	y	y	Grayburg	Per	D	Por	4,175	4,275	y	A	Lower San Andres	5,575
40	36	1.9	San Andres	Per	DL	Por	4,180	4,250	70	A	San Andres	4,557
41	37	1.1	San Andres	Per	D	Por	4,000	4,200	20	MC	San Andres	4,518
42	y	y	Grayburg	Per	D	Por	4,125	4,150	25	A	San Andres	4,510
43	34	y	Grayburg	Per	DS	Por	4,000	4,200	20	MC	Clear Fork (?)	5,200
44	34	1	Clear Fork (?)	Per	L	Por	5,100	5,150	5	A	Clear Fork (?)	5,200
45	y	y	San Andres	Per	D	Por	4,315	4,360	18	A	Clear Fork	6,422
46	35	2.6	San Andres	Per	D	Por	3,550	3,675	30	A	San Andres	4,002
47	y	y	Grayburg	Per	D & S	Por	4,060	4,208	25	A	San Andres	4,480
48	33	2.1	San Andres	Per	D	Por	4,650	4,900	25	A	San Andres	5,885
49	y	y	San Andres	Per	D	Por	5,910	5,950	40	A	Clear Fork	7,776
50	34	y	San Andres	Per	D	Por	5,000	5,370	90	A	San Andres	5,477
51	34	y	Clear Fork	Per	D	Por	6,210	6,881	y	x	y	11,108
52	34	y	y	Per	D	Por	7,055	7,433	y	y	y	11,108
53	34	1.8	San Andres	Per	D	Por	4,900	5,200	50	AM	y	11,108
54	y	y	San Andres	Per	DL	Por	2,800	2,920	20	A	San Andres	2,940
55	y	y	San Andres	Per	D	Por	2,632	2,669	y	A	San Andres	2,669
56	y	y	Data on producing formation and deepest zone tested included separately									
57	32	1	Yates	Per	S	Por	1,280	1,400	20	A	Ellenburger	10,906
58	32	0.8	Seven Rivers (?)	Per	S	20	1,650	1,900	20	A	Ellenburger	10,906
59	30	1.6	Grayburg (?)	Per	DL	Por	2,150	2,300	30	A	Ellenburger	10,906
60	30	0.9	San Andres	Per	DL	Por	2,400	2,500	30	A	Ellenburger	10,906
61	27	3.4	San Andres-Clear Fork	Per	DL & S	Por	2,900	3,000	20	A	Ellenburger	10,906
62	27	1.9	Clear Fork	Per	D	Por	2,450	2,800	50	A	Wichita (?)	4,220

TABLE 1.—(*Continued*)

Line Number	*County*, Field	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
63	*Howard:* Moore	1938	640	0	95,059	16,801
64	Snyder	1937	1,200	0	2,323,884	278,191
65	*Irion:* Irion	1929	340	0	140,811	360
66	*Kimble:* Bolt	1938	40	0	2,084	832
67	*Loving:* Mason	1936	350	0	496,050	58,716
68	Wheat	1925	4,060	0	8,911,640	337,850
69	*Lubbock:* Lubbock	1941	40	0	3,548	2,353
70	Stinnett	1942	40	0	986	986
71	*McCullough:* Melvin (McCullough)	1938	100	0	854	259
72	*Mitchell:* Westbrook	1921	4,060	0	9,405,687	222,998
73	*Pecos:* Abell	1940	3,120	200	932,190	735,255
74	McKee sand	1940	2,360	80		
75	Waddell sand	1941	400	120		
76	Ellenberger	1941	360	0		
77	Abell Permian	1941	840	0	92,622	78,330
78	2300-foot pay	1941	200	0		
79	3800-foot pay	1941	200	0		
80	3200-foot pay	1941	40	0		
81	3350-foot pay	1941	80	0		
82	3900-foot pay	1941	320	0		
83	Apco-Warner	1939	840	0	264,499	110,244
84	Chancellor	1942	80	0	16,093	16,093
85	Fromme	1939	320	0	94,091	22,382
86	Grass roots	1940	*x*	0	739	270
87	Heiner	1941	40	0	5,952	2,124
88	Jamison & Pollard	1941	40	0	48,447	27,247
89	Lehn	1939	1,200	0	381,948	91,139
90	Masterson	1927	240	0	973,511	46,860
91	Netterville	1934	800	0	388,407	23,980
92	Pecos Valley high gravity	1928	1,300	0	1,664,661	190,438
93	Pecos Valley low gravity	1928	2,160	0	1,015,355	110,148
94	Richards	1929	160	0	30,171	1,406
95	Shearer	1938	480	0	1,211,311	182,707
96	Taylor Link	1929	2,460	0	7,665,240	608,617
97	Tohorg	1928	1,320	0	7,409,253	479,037
98	Walker	1940	2,520	0	406,204	244,009
99	Wentz	1941	160	0	23,666	22,128
100	White and Baker	1935	800	480	252,150	84,785
101	Yates	1926	20,000	0	266,511,547	6,640,318
102	Yates sand	1933	700	0	505,548	38,659
103	*Pecos and Ward:* Payton	1937	1,770	0	2,872,605	326,180
104	*Reagan:* Barnhart	1941	1,440	0	117,474	103,096
105	Big Lake, 2400-foot pay }	1923	275	0		
106	3000-foot pay }	1923	3,000	0	69,612,445	1,288,862
107	4300-foot pay }	1942	40	0		
108	Ordovician	1928	640	0	28,584,664	539,015
109	Grayson	1928	640	0	646,403	17,254
110	*Reeves:* Anthony	1939	20	0	2,524	22
111	*Runnels:* Beddo	1938	70	0	98,130	46,013
112	Huddleston	1940	20	0	14,751	2,093
113	McMillan	1927	190	0	958,069	2,006
114	*Schleicher:* Page	1939	160	1,000	40,417	7,859
115	*Scurry:* Sharon Ridge (deep) }	1938	3,400	0	1,357,160	419,727
116	*Scurry and Mitchell:* Sharon Ridge (shallow) }	1924	3,800	0		
117	*Tom Green:* Funk	1940	20	0	711	351
118	*Upton:* Herrington	1937	100	0	85,044	9,685
119	Hurdle	1936	600	0	241,950	16,863
120	McCamey	1925	19,200	0	54,443,482	3,196,900
121	Webb Ray	1935	160	0	68,218	3,972
122	*Ward:* Byrd	1942	160	0	7,844	7,844
123	Dobbs	1936	160	0	20,028	2,083
124	Estes	1936	4,500	0	14,171,367	1,467,118
125	Magnolia Sealy	1938	1,000	0	1,008,014	226,851
126	Magnolia Sealy South	1940	1,200	0	256,125	167,750

TABLE I.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]
				During 1942		End of 1942			Number of Wells				
	To End of 1942	During 1942[1]	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[e]	Flowing	Artificial Lift	Initial	Avg. at End of 1942	
63	*x*	*x*	7	1	0	0	7	0	0	7	*x*	*x*	
64	*x*	*x*	99	2	0	0	99	0	0	99	*x*	*x*	
65	*x*	*x*	17	0	5	2	0	0	0	0	*x*	*x*	
66	*x*	*x*	2	1	0	0	2	0	1	1	*x*	*x*	
67	*x*	50.5	10	0	0	1	9	0	5	4	*x*	*x*	
68	*x*	260.1	90	0	2	2	86	0	37	49	*x*	*x*	
69	*x*	*x*	1	0	0	0	1	0	0	1	1,634	1,634	
70	*y*	*y*	1	1	0	1	1	0	1	0	*y*	*y*	
71	*x*	*x*	*y*	1	0	1	0	0	0	1	*x*	*x*	
72	*x*	*x*	139	0	0	0	87	0	0	87	*x*	*x*	
73	*x*	626.4	83	31	0	0	78	5	75	3	*x*	*x*	
74	*x*	*y*	61	16	0	0	59	2	58	1	*x*	2,290	
75	*x*	*y*	13	7	0	0	10	3	10	0	*x*	2,545	
76	*x*	*y*	9	8	0	0	9	0	7	2	*x*	2,680	
77	*x*	62.7	21	13	0	0	21	0	13	8	*x*	*x*	
78	*x*	*y*	5	3	0	0	5	0	4	1	*x*	1,225	
79	*x*	*y*	5	3	0	0	5	0	5	0	*x*	1,809	
80	*x*	*y*	2	1	0	0	2	0	1	1	*x*	*x*	
81	*x*	*y*	1	0	0	0	1	0	1	0	*x*	*x*	
82	*x*	*y*	8	6	0	0	8	0	2	6	*x*	1,575	
83	*x*	94.3	21	10	0	0	21	0	20	1	*x*	*x*	
84	*x*	*x*	2	2	0	0	2	0	2	0	*x*	*x*	
85	*x*	*x*	11	1	0	0	11	0	7	4	*x*	*x*	
86	*x*	*x*	3	0	0	3	0	0	0	0	*x*	*x*	
87	10.3	7.7	1	0	0	0	1	0	1	0	*x*	*x*	
88	*x*	*x*	1	0	0	0	1	0	1	0	*x*	*x*	
89	*x*	95.4	50	4	0	0	50	0	27	23	*x*	*x*	
90	*x*	*x*	24	0	0	0	24	0	0	24	*x*	*x*	
91	*x*	*x*	21	0	0	4	17	0	12	5	*x*	*x*	
92	*x*	191.0	102	0	0	1	100	0	42	58	*x*	*x*	
93	*x*	87.6	78	0	0	5	73	0	26	47	*x*	*x*	
94	*x*	*x*	3	0	0	0	3	0	0	3	*x*	*x*	
95	*x*	134.8	48	0	4	0	43	0	10	33	*x*	*x*	
96	*x*	*x*	123	14	0	0	123	0	9	114	*x*	*x*	
97	*x*	*x*	253	1	0	0	253	0	19	234	*x*	*x*	
98	*x*	283.5	63	24	0	0	63	0	52	11	*x*	*x*	
99	*x*	*x*	2	1	0	0	2	0	0	2	*x*	1,399	
100	*x*	131.0	23	2	0	0	20	3	20	0	*x*	*x*	
101	120,487.0	1,331.7	558	1	1	3	555	0	515	40	700	524.5	
102	*x*	*x*	10	0	0	0	10	0	0	10	*x*	*x*	
103	*x*	356.8	141	0	5	0	123	0	20	103	*x*	*x*	
104	212.0	185.6	9	7	0	0	9	0	9	0	3,915	3,900	
105	*x*	*x*	21	0	0	0	4	0	0	4	*x*	*x*	
106	*x*	*x*	261	0	0	3	182	0	0	182	*x*	*x*	
107	*x*	*x*	1	1	0	1	1	0	1	0	*x*	*x*	
108	*x*	*x*	25	0	0	1	14	1	7	7	3,600	*y*	
109	*x*	*x*	5	0	0	0	5	0	0	5	*x*	*x*	
110	*x*	*x*	1	0	0	1	0	0	0	0	*x*	*x*	
111	*x*	*x*	7	2	0	0	6	0	0	6	*x*	*x*	
112	*x*	*x*	2	0	0	1	1	0	1	0	*x*	*x*	
113	*x*	*x*	19	0	0	1	2	0	0	2	*x*	*x*	
114	*x*	*y*	5	0	0	0	1	4	1	0	2,056	*x*	
115	*x*	*x*	106	8	0	1	105	0	8	97	*x*	*x*	
116	*x*	*x*	71	5	0	3	68	0	0	68	*x*	*x*	
117	*x*	*x*	1	0	0	1	0	0	0	1	*x*	*x*	
118	*x*	*x*	2	0	0	0	2	0	0	2	*x*	*x*	
119	*x*	*x*	18	0	0	0	12	0	0	12	*x*	*x*	
120	*x*	*x*	934	0	0	6	852	0	13	839	*x*	*x*	
121	*x*	*x*	5	0	0	0	2	0	0	2	*x*	*x*	
122	*x*	*x*	4	4	0	0	4	0	4	0	1,141	1,141	
123	*x*	*x*	2	0	0	0	1	0	0	1	*x*	*x*	
124	*x*	4,979.4	349	0	0	8	341	0	211	130	1,370	*x*	RP
125	*x*	211.7	55	0	0	2	53	0	3	50	1,400	*x*	
126	*x*	119.1	19	5	0	0	19	0	18	1	1,445	1,394	

TABLE I.—(*Continued*)

Line Number	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age^e	Character^f	Porosity^g	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure^h	Name	Depth of Hole, Ft.
63	*y*	2.3	Grayburg	Per	DL	Por	3,197	3,200	3	*y*	Grayburg	3,205
64	30.1	*y*	San Angelo	Per	DL	Por	2,650	2,825	*y*	A	Clear Fork	3,750
65	38	0	San Angelo	Per	S	Por	1,370	1,410	10	ML	Wichita (?)	3,972
66	27.8	*y*	Strawn	Pen	S	Por	1,415	1,430	10	AF	Ellenburger	2,074
67	39	0.1	Delaware Mt.	Per	S	Por	3,930	3,950	10	T	Delaware Mt.	4,165
68	38	0.1	Delaware Mt.	Per	S	Por	4,290	4,310	7	MC	Delaware Mt.	5,083
69	28	*y*	Clear Fork	Per	D	Por	4,870	5,002	*y*	?	Clear Fork	5,002
70	*y*	*y*	Clear Fork	Per	D	Por	4,690	5,372	*y*	?	Wichita	7,000
71	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*	*y*
72	23	3.5	Clear Fork	Per	D	Por	2,800	3,000	50	MC	Wichita (?)	5,250
73	*x*	*x*	Data on producing formation and deepest zone tested included separately									
74	44	*y*	Middle Simpson	Ord	S	Por	5,295	5,335	20	AF	Ellenberger	6,483
75	42	*y*	Lower Simpson	Ord	S	Por	5,775	5,750	10	A	Ellenberger	6,483
76	41	*y*	Ellenberger	Ord	D	Por	5,830	5,905	25	A	Ellenberger	6,483
77	*x*	*x*	Data on producing formation and deepest zone tested included separately									
78	37	*y*	San Andres	Per	D	Por	2,275	2,310	20	A	Pre-Cambrian	5,745
79	32	*y*	Wichita	Per	D	Por	3,750	3,840	30	A	Pre-Cambrian	5,745
80	26	*y*	Lower San Andres	Per	D	Por	3,210	3,320	30	A	Ellenberger	6,483
81	36	*y*	Upper Clear Fork	Per	D	Por	3,350	4,470	20	A	Ellenberger	6,483
82	36	*y*	Wichita	Per	D	Por	3,895	3,945	40	A	Ellenberger	6,483
83	41	*y*	Ellenburger	Ord	D	Cav	4,550	4,580	20	A	Pre-Cambrian	4,526
84	*y*	*y*	Delaware	Per	S	Por	5,075	5,173	5	H	Delaware	6,001
85	27	*y*	Queen	Per	S-D	Por	1,412	1,443	15	D	San Andres	1,674
86	17	0	Paluxy	Cre	S	Por	50	60	*y*	*y*	Devonian	6,473
87	35.8	*y*	Ellenburger	Ord	D	Por	5,382	5,389	*x*	*x*	Ellenburger	5,665
88	24.4	*y*	San Andres	Per	D	Por	2,037	2,041	4	*x*	San Andres	2,550
89	34	*y*	Queen	Per	S	Por	1,675	1,700	10	A	Grayburg	1,995
90	28	1.4	Queen	Per	S	Por	1,200	1,400	5	M	Pre-Cambrian	4,526
91	41	*y*	Yates sand	Per	S	Por	1,300	1,600	15	A	San Andres	2,550
92	38	1.6	Yates sand	Per	S	Por	1,875	1,950	15	A	San Andres	2,253
93	25	*y*	Yates sand	Per	S	Por	1,500	1,650	15	A	Ellenburger	5,665
94	17	0	Dewey Lake	Per	S	Por	1,380	1,397	10	*x*	San Andres	4,360
95	35	*y*	Seven Rivers	Per	S	Por	1,415	1,465	*y*	*y*	Pre-Cambrian	4,526
96	29	1.3	Yates sand, Queen, San Andres	Per	D-S	Por	1,580	1,650	25	A	San Andres	1,845
97	19	2.1	Tobarg	Cre	S	Por	400	445	15	AL	San Andres	1,400
98	31.2	1.4	Queen	Per	S	22	2,065	2,080	15	A	Ellenburger	9,811
99	33.7	*y*	Ellenburger	Ord	D	Por	4,307	4,383	20	*x*	Pre-Cambrian	4,493
100	31.5	1.4	Queen	Per	S-D	22	1,650	1,700	10	A	Lower Ordovician	9,811
101	30	1.6	San Andres	Per	D	Por	1,310	1,450	100	A	San Andres	1,938
102	32	1.5	Yates sand	Per	S	Por	900	1,100	15	AL	San Andres	1,852
103	33.5	1.1	Yates sand	Per	S	Por	2,000	2,080	40	A	San Andres	3,200
104	44.2	*y*	Ellenburger	Per	D	Por	9,016	9,082	30	*x*	Ellenburger	9,294
105	35	0.3	Queen	Per	S	Por	2,375	2,500	40	A	Ellenburger	9,562
106	36	0.36	San Andres	Per	L-D	Por	2,960	3,000	60	A-D	Ellenburger	9,562
107	*y*	*y*	Word	Per	S	Por	4,212	4,383	*y*	ML	Ellenburger	9,562
108	44	0.18	Ellenburger	Ord	D	Por	8,200	8,900	*x*	A	Ellenburger	9,562
109	32	0.58	San Andres	Per	D-L	Por	3,050	3,100	*y*	D	Devonian	9,967
110	30	*y*	Upper Castile	Per	D	Por	1,618	1,630	*y*	*x*	Upper Castile	1,900
111	42	*y*	*y*	Pen	S	Por	2,366	2,388	22	N	*y*	*y*
112	39	*y*	Palo Pinto	Pen	L	Por	3,557	3,583	26	N	Palo Pinto	*y*
113	41	*y*	Graham	Pen	S	Por	2,550	2,562	12	N	*y*	*y*
114	41	*y*	Strawn	Pen	L	Por	5,485	5,560	50	A	Bend (?)	6,257
115	30	*y*	San Angelo and Clear Fork	Per	D & S	Por	2,250	2,450	*y*	A	Wichita	3,545
116	29	2	San Andres	Per	DL	Por	1,650	1,750	*y*	A	Wolfcamp	4,524
117	33	*y*	San Andres	Per	DL	Por	1,123	1,127	4	MC	Clear Fork	1,560
118	24	*y*	Grayburg	Per	DL	Por	2,800	2,850	*y*	A	Grayburg	2,963
119	25	*y*	Grayburg	Per	DL	Por	2,050	2,100	*y*	A	Lower Permian	3,085
120	28	*y*	Grayburg-San Andres	Per	DL	Por	2,100	2,200	30	A	Wichita	4,610
121	25	*y*	Grayburg	Per	DL	Por	2,060	2,150	*y*	A	San Andres	2,176
122	*y*	*y*	Capitan	Per	S-D	Por	2,611	2,637	*y*	A	Capitan	2,885
123	37	*y*	Queen	Per	S	Por	2,550	2,570	7	*y*	Grayburg (?)	2,600
124	34	1.2	Yates sand	Per	S & D	Por	2,450	2,950	50	A	Queen	3,274
125	32.7	*y*	Seven Rivers	Per	OD	Por	2,878	2,952	30	A	Queen	3,175
126	28	*y*	Seven Rivers	Per	OD	Por	2,890	2,910	15	A	Queen	3,277

Texas-New Mexico crude went into storage during the year.

Because of the voluntary adoption of the 40-acre well-spacing pattern already in effect in some of the newer and larger fields, compliance with spacing regulations of the Office of Petroleum Coordinator restricted drilling to only a minor extent.

While stocks of critical materials were not reduced to the point of preventing drilling, the fear that a shortage might develop may have influenced some operators to defer drilling, as there was no assurance of adequate materials should a new field be opened to intensive competitive development.

While these and other factors may have retarded development to some extent, the principal reason for the reduction in drilling was the lack of attractive acreage available for exploitation. The most extensive development during the year was confined to the Slaughter, Barnhart and Andrews County fields.

As in 1941, the more significant wildcatting was done in pre-Permian exploration. The wildcatting tends to confirm the belief that pre-Permian production may be found extensively over the area and that it may compare favorably in reserves with the present established production from Permian fields. Owing to the increased depth and the greater structural relief of the pre-Permian horizons, improvements in all our exploration methods, including geophysical technique, are needed to guide the wildcatter in his search for oil-producing structures in the older beds, which in many places appear to be effectively concealed underneath relatively undisturbed Permian strata.

TABLE 1.—(*Continued*)

Line Number	*County*, Field	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
127	*Ward:* Monahans	1942	160	0	33,608	33,608
128	Monahans Permian	1942	320	0	5,830	5,830
129	Monroe	1930	80	0	79,562	5,953
130	Nichols	1942	40	0	1,041	1,041
131	North Ward	1929	10,000	y	25,079,353	2,018,546
132	Pruitt	1942	40	0	1,552	1,552
133	Pyote	1942	80	0	22,375	22,375
134	Shipley	1928	640	0	5,662,028	444,405
135	Shipley Silurian	1940	80	0	34,570	12,447
136	South Ward	1930	1,180	y	27,138,827	975,197
137	Spencer	1941	800	0	52,854	43,435
138	*Winkler:* Eaves	1936	320	0	704,673	154,017
139	Emperor deep	1940	1,600	y	904,826	116,715
140	Emperor Shallow	1936	2,000	360	2,462,787	374,694
141	Halley	1935	820	0	959,992	83,497
142	Henderson	1935	2,800	0	6,323,954	1,126,109
143	Hendrick	1927	12,138	0	204,345,863	2,512,225
144	Kermit	1928	15,240	y	29,696,335	1,698,582
145	Keystone Colby sand	1930	7,000	y	9,556,012	1,248,940
146	Keystone Lime	1935	9,500	y		454,079
147	Leck	1927	960	0	3,905,320	154,709
148	Scharborough	1927	3,790	0	6,941,436	457,861
149	Weiner	1941	800	0	83,157	81,707
150	*Yoakum:* Ownby	1941	480	0	71,488	46,073
151	Waples-Platter	1939	600	0	63,762	22,318
152	West	1938	40	0	42,589	8,348

Some economic adjustment either in price or in daily production rate is needed to compensate for the increased discovery, development and operational costs of pre-Permian production. While it is difficult to estimate reserves from discovery wells, it is believed that the new fields brought into production during 1942 added more reserves than the production withdrawals during the year. It is also believed that the present developed reserves are adequate to maintain the present pipe-line capacity for several years.

With the rapid depletion of the gas-driven sand fields, more attention is being given to the possibilities afforded by secondary-recovery methods. As the gas-injection projects have not shown impressive results, an experimental water-flooding project is being tried in the Estes field. About 500 bbl. of filtered but untreated lease water per day under pump pressures of 500 and 985 lb. is being injected in each of two wells, one 2600 and the other 2900 ft. deep. Depleted oil wells are being used as injection wells and no new drilling to modify the 10-acre and greater well spacing is contemplated at the present time.

The Illinois Pipe Line Co. removed 136 miles of looped 8-in. from the Yates field to Del Rio and 124 miles of looped 10-in. from Del Rio to Lytle, Texas, at which point the company had connected to the Humble pipe-line system. The Shell Pipe Line Co. purchased the 6-in. Basin pipe line running from the Wasson field to Big Spring and laid a line from Big Spring to Colorado, Texas, to connect with its trunk-line system at that point. Feeder pipe lines were laid by the Texas-New Mexico Pipe Line Co. and Gulf Pipe Line Co. to serve the Abell and Sand Hills fields. The present trunk lines

TABLE 1.—(*Continued*)

Line Number	Total Gas Production, Millions Cu. Ft.		Number of Oil and/or Gas Wells						Oil-production Methods, End of 1942		Reservoir Pressure, Lb. per Sq. In.		Repressuring Operation[d]
				During 1942		End of 1942			Number of Wells				
	To End of 1942	During 1942[1]	Completed to End of 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil[c]	Producing Gas[c]	Flowing	Artificial Lift	Initial	Avg. at End of 1942	
127	53.8	53.8	1	1	0	0	1	0	1	0	4,700	4,700	
128	5.8	5.8	1	1	0	0	1	0	1	0	2,340	2,340	
129	x	x	2	0	0	1	1	0	1	0	x	x	
130	x	x	1	0	0	1	0	0	0	0	x	x	
131	x	6,894.2	423	9	0	0	423	0	258	165	1,400	x	RP
132	x	x	1	1	0	0	1	0	0	1	x	x	
133	x	x	2	2	0	0	2	0	2	0	x	x	
134	x	126.7	126	6	0	0	126	0	10	116	x	x	
135	x	36.4	2	0	0	0	2	0	2	0	x	x	
136	x	3,140.1	582	0	0	13	569	0	115	454	1,370	x	
137	28.4	25.8	10	6	0	0	10	0	9	1	1,435	1,381	
138	x	x	7	0	0	0	7	0	2	5	x	x	
139	x	218.5	48	0	0	9	39	0	26	13	x	x	
140	x	1,132.3	81	9	0	0	81	y	74	7	1,300	x	
141	x	181.3	25	0	0	0	25	0	3	22	1,235	x	
142	4,048.9	603.4	139	0	0	1	138	0	119	19	1,450	1,282	
143	x	x	425	0	2	0	296	0	56	240	1,720	x	
144	x	9,114.5	848	0	0	9	818	y	168	650	1,450	x	RP
145	x	1,968.3	258	28	0	0	258	y	204	54	1,550	1,273	
146	x	2,389.4	104	13	0	0	104	y	80	24	x	x	
147	x	x	9	0	0	0	9	0	1	8	x	x	
148	x	1,303.0	134	0	0	2	132	0	88	44	1,450	x	RP
149	233.0	227.6	19	18	0	0	19	0	19	0	1,270	1,270	
150	45.4	42.3	6	1	0	0	6	0	6	0	1,638	1,563	
151	x	14.0	4	2	0	0	4	0	3	1	1,465	1,297	
152	x	x	1	0	0	0	1	0	0	1	x	x	

serving West Texas and southeastern New Mexico have a capacity of 401,000 bbl. per day. During the year, the pipe lines moved 97,331,995 bbl. of crude from West Texas, Lea and Eddy Counties, New Mexico.

Authorization was obtained from the Railroad Commission of Texas to place the "Production Unit Plan" in operation in the Goldsmith field. Under this plan, the operators are permitted to shut in half of the wells and transfer the allowable of the wells of higher gas-oil ratio to those of lower gas-oil ratio, on any basic lease not exceeding 320 acres in size. As the Goldsmith field was drilled on a well spacing of 20 acres, the unit plan permits simulation of development of one well to 40 acres, which is believed adequate for economic recovery at the current production rate for the field. While the plan has been in effect too short a time to determine the ultimate effect, there has been an immediate reduction in current gas production. The unitized leases connected to the gasoline plant for December had a gas-oil ratio 27.22 per cent below those of June 1942, whereas the gas-oil ratio of the nonunitized leases was 2.3 per cent below those of June, resulting in an over-all reduction in gas-oil ratio of 23.36 per cent for the 805 wells connected to the gasoline plant. Similar plans have been placed in effect in the Estes, North Ward and Sand Hills (Permian) fields.

To any one interested in making reservoir studies or charged with estimation of recoverable oil, the task is exceedingly difficult in any of the West Texas fields, because of lack of sufficient core data, bottom-hole pressure information, and accurate per-well records of oil, gas and water withdrawals. In order to control most efficiently the production of oil, it is neces-

TABLE 1.—(*Continued*)

	Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
							Depth, Avg. Ft.					
Line Number	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent	Name	Age[e]	Character[f]	Porosity[g]	Top Prod. Zone	Bottoms Prod. Wells	Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
127	47	0	Ellenburger	Ord	D	Frac. Cav	10,082	10,353	x	A	Ellenburger	10,545
128	34.5	y	San Andres	Per	D	Por	5,631	5,651	20	A	Ellenburger	10,545
129	29	0.14	Delaware sand	Per	S	Por	4,665	4,675	5	T	Delaware sand	4,692
130	y	y	Whitehorse	Per	LS	Por	2,400	2,449	y	(?)	Whitehorse	2,449
131	36	1.0	Yates sand	Per	D-S	Por	2,500	2,750	40	ML	San Andres	4,825
132	y	y	Delaware sand	Per	S	Por	4,831	4,869	y	A	Delaware sand	4,869
133	y	y	Capitan	Per	D	Por	2,827	2,841	y	A	Capitan	3,100
134	34	1.8	Seven Rivers	Per	DS	Por	2,900	3,100	50	A	Ellenburger	9,187
135	32.2	0	Silurian	Sil	L	Por	7,018	7,075	x	x	Ellenburger	9,187
136	32	1.3	Seven Rivers	Per	S	Por	2,300	2,525	40	ML	Wichita (?)	4,825
137	28	y	Seven Rivers	Per	OD	Por	2,930	2,960	20	A	Seven Rivers	2,990
138	26	y	Yates sand	Per	DS	Por	3,100	3,170	20	A	Seven Rivers	3,175
139	y	y	Seven Rivers	Per	OD	Por	2,785	3,040	20	AC	Seven Rivers	3,145
140	33	y	Yates sand	Per	S	Por	2,833	3,100	40	AC	Seven Rivers	3,145
141	31.1	y	Yates sand	Per	S	Por	3,100	3,200	22	AC	San Andres	3,855
142	30	1.1	Seven Rivers	Per	OD	Por	3,025	3,075	30	A	Grayburg (?)	3,450
143	28	1.4	Seven Rivers	Per	OD	Por	2,600	2,900	y	A	San Andres	3,920
144	35	y	Yates sand	Per	DS	Por	2,825	3,200	10	A	Grayburg	3,414
145	36	y	Grayburg	Per	S	Por	3,215	3,313	y	A	San Andres	3,702
146	36.5	0.8	Grayburg, San Andres	Per	D & S	Por	3,210	3,360	y	A	San Andres	3,702
147	28	1.6	Seven Rivers	Per	OD	Por	3,000	3,100	y	A	San Andres	3,780
148	35	1.0	Yates sand	Per	DS	Por	2,800	3,050	10	A	Grayburg (?)	3,565
149	33.5	y	Queen	Per	S	Por	3,005	3,210	y	y	Queen	3,210
150	27	0.1	San Andres	Per	D	Por	5,235	5,360	27	A	San Andres	5,700
151	32.5	0.1	San Andres	Per	D	Por	5,200	5,300	25	A	San Andres	5,370
152	31	y	San Andres	Per	D	Por	5,168	5,255	10	MC	San Andres	5,255

TABLE 2.—*Summary of Drilling Operations in West Texas*

Important Wildcats Drilled in 1942

	County	Location			Total Depth, Ft.	Surface Formation
		Sec.	Blk.	Survey		
1	Andrews	15	A-32	P.S.L.	8,005 P.B.	Tertiary to Recent
2	Andrews	27	10	State University	4,514	Tertiary to Recent
3	Andrews	16	10	State University	4,599	Tertiary to Recent
4	Andrews	30	10	State University	7,855	Tertiary to Recent
5	Andrews	32	10	State University	6,275 P.B.	Tertiary to Recent
6	Andrews	13	A-42	P.S.L.	4,594	Tertiary to Recent
7	Andrews	10	10	State University	4,580	Tertiary to Recent
8	Andrews	14	10	State University	4,640	Tertiary to Recent
9	Andrews	2	11	State University	4,437	Tertiary to Recent
10	Andrews	9	12	State University	10,760	Tertiary to Recent
11	Andrews	24	A-29	P.S.L.	9,440	Tertiary to Recent
12	Cochran	Lab. 12	Lge. 60	Martin Co. S.L.	4,983	Tertiary to Recent
13	Cochran	Lab. 14	Lge. 61	Martin Co. S.L.	4,998	Tertiary to Recent
14	Coke	276	1-A	H. & T.C.	3,828	Blaine
15	Crane	20	1	H. & T.C.	6,186	Recent
16	Crane	5	31	H. & T.C.	5,743	Recent
17	Crane	19	42	T-4-S T. & P.	6,209	Comanchean
18	Crockett	16	10	G.C. & S.F.	7,078	Comanchean
19	Crockett	30	QR	G.C. & S.F.	6,523	Comanchean
20	Crockett	68	1	I. & G.N.	6,977	Comanchean
21	Crockett		Lge. 1	Archer Co. S.L.	2,070	Comanchean
22	Crockett		Lge. 1	Archer Co. S.L.	2,089	Comanchean
23	Dickens	5	1	Shook & Arnold	6,314	White horse
24	Ector	48	44	T-1-S T. & P.	4,353 P.B.	Recent
25	Gaines	13	A-7	P.S.L.	6,438	Tertiary to Recent
26	Gaines	25	A-21	P.S.L.	5,950 P.B.	Tertiary to Recent
27	Garza	6	5	K. Aycock	2,924	(?)
28	Hockley	15	A	R. M. Thompson	6,000	Tertiary to Recent
29	Hockley	Lab. 21	Lge. 717	State Capital L.	6,500	Tertiary to Recent
30	Howard	37	30	T-1-N T. & P.	2,750 P.B.	Triassic (?)
31	Howard	42	29	T-1-N T. & P.	2,727	Triassic (?)
32	Hudspeth	24	73	Twp. 7 T. & P.	6,226	Recent
33	Hudspeth	34	74	Twp. 6 T. & P.	6,402	Recent
34	Lubbock	64	20	H.E. & W.T.	6,406	Tertiary to Recent
35	Lubbock	Lab. 18	Lge. 4	San Augustine S.L.	5,372 P.B.	Tertiary to Recent
36	Lubbock	33	D-5	E.L. & R.R.	6,410	Tertiary to Recent
37	Martin	18	35	T-1-N T. & P.	8,318	Tertiary to Recent
38	Midland	24	39	T-3-S T. & P.	6,104	Tertiary to Recent
39	Pecos	60	10	H. & G.N.	5,200	Tertiary to Recent
40	Pecos	30	140	T. & S.T.L.	6,652	Tertiary to Recent
41	Pecos	98	10	H. & G.N.	5,318	Tertiary to Recent
42	Pecos	90	194	G.C. & S.F.	1,932	Comanchean
43	Pecos	46	12	H. & G.N.	5,666	Comanchean
44	Pecos	135	10	H. & G.N.	4,150	Recent
45	Pecos	43	11	H. & G.N.	4,406	Comanchean
46	Pecos	26	16	State University	1,732	Comanchean
47	Pecos	26	16	State University	1,720	Comanchean
48	Pecos	4	12	H. & G.N.	5,506	Comanchean
49	Pecos	31	49	T-10 T. & P.	5,274 P.B.	Comanchean
50	Pecos	36	50	T-10 T. & P.	5,072	Comanchean
51	Pecos	15	2	H. & T.C.	3,945	Recent
52	Reagan	24	9	State University	4,383	Comanchean
53	Reeves	18	C-7	P.S.L.	5,267	Recent
54	Sterling	28	12	S.P.R.R.	8,117	Comanchean
55	Sutton	91	9	T.W.N.G.	4,676	Comanchean
56	Sutton	44	K	G.H. & S.A.	5,416	Comanchean
57	Terry	91	4-x	E.L. & R.R.	6,870	Tertiary to Recent
58	Upton		P. B. Scott	50½	10,384	Comanchean
59	Ward	19	16	State University	2,847	Recent
60	Ward	23	1	W. & N.W.	4,869	Recent
61	Ward	5	5	H. & T.G.	2,449	Recent
62	Ward	38	A	G. & M.M.B. & A.	10,364 P.B.	Recent
63	Ward	38	A	G. & M.M.B. & A.	5,660 P.B.	Recent
64	Ward	34	34	H. & T.C.	2,679 P.B.	Recent
65	Winkler	24	B-5	P.S.L.	3,187 P.B.	Recent
66	Yoakum	436	D	J. H. Gibson	5,600	Recent

	In Proven Fields	Wildcats
Number of wells drilling Dec. 31, 1942	154	26
Number of oil wells completed during 1942	1,052	36
Number of gas wells completed during 1942	10	1
Number of dry holes completed during 1942	69	99

sary to obtain complete and accurate data on well completion, subsequent remedial work, accurate records on oil, gas and water production, and periodic subsurface pressures. It is hoped that under the stimulus of the various conservation agencies the quality and completeness of this type of information may improve.

As the data presented in Table 1 have been compiled from many sources, it may

TABLE 2.—(*Continued*)

Important Wildcats Drilled in 1942

	Deepest Horizon Tested	Drilled by	Initial Production per Day Oil, U. S. Bbl.	Choke or Bean, Fractions of an Inch	Remarks
1	Wichita (?)	Fullerton Oil Co.	682	1-in. tbg.	Discovery Fullerton field
2	San Andres	Wheelock & Cross	178	Pump	Discovery Mascho field
3	San Andres	Mid Continent Petr. Corp.	95	Pump	Extension, Mascho field
4	Ellenburger	Phillips Petr. Co.	2,892	Open tbg.	Discovery Embar field
5	Ellenburger	Phillips Petr. Co.	264		Discovery Tubb pay, Embar field
6	San Andres	Seaboard Oil Co.	66	Gas lift	Extension West Fuhrman field
7	San Andres	Siemoneit Drill. Co.	201	Pump	Extension West Fuhrman field
8	San Andres	Skelly Oil Co.	76	Pump	Extension Mascho field
9	San Andres	Stanolind Oil & Gas Co.	35		Extension West Andrews field
10	Ellenburger	Atlantic Ref. Co.			Dry and abandoned
11	Permo-Penn (?)	Humble Oil & Ref. Co.			Dry and abandoned
12	San Andres	Bieg Oil Co.	450	Pump	Extension Slaughter field
13	San Andres	Sunray Oil Co.	238	Pump	Extension Slaughter field
14	Cisco (?)	W. F. Morgan	175	Pump	Discovery Blackwell field
15	Simpson	Magnolia Petr. Co.	226	¼	Discovery McKee field
16	Ellenburger	Skelly Oil Co.			Dry and abandoned
17	San Andres	Texas Company			Dry and abandoned
18	Ellenburger	Amerada Petr. Corp.			Dry and abandoned
19	Wolfcamp	J. B. Moncrief & Helmerich & Payne			Dry and abandoned
20	Ellenburger	Moore Bros. & Olson Drill. Co.			Dry and abandoned
21	San Andres	Olson Oil Co.	99	Pump	Extension Olson field
22	San Andres	Sun Oil Co.	364	Pump	Extension Olson field
23	Strawn	Humble Oil & Ref. Co.			Dry and abandoned
24	San Andres	Oil Well Drill. Co.	20	½	Discovery (undesignated)
25	San Angelo	Likens & Hall			Dry and abandoned
26	Clear Fork	Texas Company	298	Pump	Discovery Robertson field
27	San Andres	M. L. Richards	101	Pump	Extension Garza field
28	Clear Fork	Anderson Prichard Oil Corp.			Dry and abandoned
29	Clear Fork	Stanolind Oil & Gas Co.			Dry and abandoned
30	Clear Fork	Ray Oil Co.	222	Pump	Extension Iatan-East Howard field
31	San Angelo	Ray Oil Co.	220	Pump	Extension Iatan-East Howard field
32	Bone Spring (?)	Hayman Krupp Oil & Land Co.			Dry and abandoned
33	Bone Spring (?)	Hayman Krupp Oil & Land Co.			Dry and abandoned
34	Clear Fork (?)	Geo. P. Livermore			Dry and abandoned
35	Clear Fork (?)	Stanolind Oil & Gas Co.	66	Pump	Discovery Stinnett field
36	Clear Fork (?)	J. R. Sharpe			Dry and abandoned
37	Clear Fork (?)	Magnolia Petr. Co.			Dry and abandoned
38	Leonard	Broderick & Calvert & Geo. P. Livermore			Dry and abandoned
39	Ellenburger	Anderson Prichard Oil Corp.			Dry and abandoned
40	Simpson	Anderson Prichard Oil Corp.			Dry and abandoned
41	Ellenburger	Anderson Prichard & Magnolia Petr. Co.			Dry and abandoned
42	Whitehorse	Cardinal Oil Co.	51	1	Extension White and Bakerfield
43	Ellenburger	M. D. Bryant et al.			Dry and abandoned
44	Ellenburger	Gulf Oil Corp.			Dry and abandoned
45	Ellenburger	Gulf Oil Corp.	132	Pump	New Horizon Wents field
46	Whitehorse	J. D. Lancaster	15	Pump	Extension Walker field
47	Whitehorse	J. D. Lancaster	106		Extension Walker field
48	Ellenburger	Magnolia Petr. Co.			Dry and abandoned
49	Delaware	Pure Oil Co.	62	1	Discovery Chancellor field
50	Contact Castile-Delaware	Pure Oil Co.	682	1	New Horizon Chancellor field
51	Clear Fork	Skelly Oil Co.	577	½	Extension Abell Permian field
52	San Andres	Big Lake Oil Co.	3,424	Open tbg.	New Horizon Big Lake field
53	Delaware Mt.	Ray Johnson			Dry and abandoned
54	Ellenburger	Gulf Oil Corp.			Dry and abandoned
55	Strawn	Kingdom Oil & Gas Co.			Dry and abandoned
56	Ellenburger	Roberts & Moore			Dry and abandoned
57	San Angelo (?)	Continental Oil Co.			Dry and abandoned
58	Devonian	Plymouth Oil Co.			Dry and abandoned
59	Seven Rivers	Darby Petr. Corp.	897	2½-in. tbg.	Discovery Pyote field
60	Delaware	Fred Hyer	15/7 hr.	Died	Discovery Pruitt field
61	Whitehorse	Cross Dev. Co.	49	Pump	Discovery Nichols field
62	Ellenburger	Shell Oil Co.	961	1	Discovery Monahans field
63	Clear Fork	Shell Oil Co.	759	2 tbg.	Discovery Monahans Permian field
64	Whitehorse	Stanolind Oil & Gas Co.	29	⅛	Discovery Byrd field
65	Whitehorse	Ralph Lowe	186	1	Extension Weiner field
66	San Andres	Sinclair Prairie Oil Co.			Dry and abandoned

TABLE 3.—*Estimated Annual Production, West Texas, by Fields*
BARRELS

	County, Field	Production Unallocated by Years	1922	1923	1924	1925
1	*Andrews:* Deep Rock					
2	Embar					
3	Embar Permian					
4	Emma					
5	Fuhrman					
6	Fullerton					
7	Mascho					
8	Means					
9	Parker					
10	West Andrews					
11	West Fuhrman					
12	*Cochran:* Dean					
13	Rhodes					
14	*Cochran, Hockley and Terry:* Slaughter					
15	*Coke:* Blackwell					
16	*Concho:* Dodson					
17	*Crane:* Dune					
18	Edwards					
19	Ella Waddell					
20	McKee					
21	Sand Hills Ordovician					
22	Sand Hills Permian					
23	Waddell					
24	*Crane and Ector:* Jordan					
25	*Crane and Upton:* Crane-Cowden					
26	McElroy					
27	*Crockett:* Bean					
28	Clara Couch					
29	Crockett					
30	Hoover					
31	Live Oak					
32	Noelke					
33	Olson					
34	Simpson					
35	Todd Deep					
36	Todd Shallow					3,000
37	World					
38	Wyatt					
39	*Dawson:* Scanlon					
40	Welch					
41	*Ector:* Duoro					
42	Foster					
43	Goldsmith					
44	Harper					
45	Johnson					
46	North Cowden					
47	North Cowden Deep					
48	North Goldsmith					
49	Penwell					
50	South Cowden					
51	*Gaines:* Cedar Lake					
52	Robertson					
53	Seminole					
54	Wasson Deep					
55	Wasson "72"					
56	*Gaines and Yoakum:* Wasson					
57	*Garza:* Garza	13,294				
58	Swenson					
59	*Glasscock:* Carter					1,000
60	*Glasscock and Howard:* Howard & Glasscock					4,824
61	*Howard:* Iatan-East Howard					
62	Moore					
63	Snyder					
64	*Irion:* Irion					
65	*Kimble:* Bolt					
66	*Loving:* Mason					
67	Wheat					
68	*Lubbock:* Lubbock					
69	Stinnett					
70	*McCullough:* Melvin (McCullough)		10,000	90,294	279,181	687,281
71	*Mitchell:* Westbrook					
72	*Pecos:* Abell					
73	Abell Permian					
74	Apco-Warner					
75	Chancellor					

TABLE 3.—(*Continued*)

	1926	1927	1928	1929	1930	1931	1932	1933	1934
1								6,032	91,225
2									
3									
4									
5								7,964	83,009
6									
7									
8									22,572
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22					329	8,395	10,605	5,112	11,476
23		2,993	7,212	15,252	11,036	4,333			553
24									
25	154,049	597,504	289,963	243,274	231,572	245,681	203,024	195,176	212,690
26	467,043	23,828,460	20,880,837	13,773,314	11,610,260	6,350,901	5,663,400	4,631,855	4,482,036
27									
28									
29									
30									
31									
32									
33									
34									
35									
36									10,718
37	327,038	543,380	803,226	632,813	635,485	509,315	415,418	304,127	242,406
38									12,133
39									
40									
41									
42									
43									
44								6,570	24,662
45									
46					7,168	22,319	20,375	114,057	385,658
47									
48									
49				20,395	3,177,095	2,414,268	1,606,618	1,724,791	1,998,946
50								113,011	191,838
51									
52									
53									
54									
55									
56									
57							7,265	7,876	5,322
58									
59									
60	101,162	1,158,351	4,905,368	15,097,518	11,302,705	9,796,047	6,570,207	5,455,973	5,617,102
61	32,057	96,551	113,243	124,931	159,660	182,687	200,121	323,568	461,269
62									
63									
64					28,560	21,437	10,382	7,633	8,797
65									
66									
67	9,725	9,725	59,953	251,683	670,078	1,250,774	1,125,145	924,423	794,315
68									
69									
70									
71	1,149,357	1,151,770	890,430	693,605	589,280	503,606	433,930	397,286	350,764
72									
73									
74									
75									

TABLE 3.—(*Continued*)

	1935	1936	1937	1938	1939	1940	1941	1942	Total
1	111,858	134,114	118,622	72,037	65,704	49,236	52,056	29,319	730,203
2								101,454	101,454
3								14,040	14,040
4			2,000	58,523	279,031	248,415	358,550	285,472	1,231,991
5	297,576	254,839	389,487	455,038	540,387	504,215	456,578	250,401	3,239,494
6								112,731	112,731
7								7,072	7,072
8	209,353	459,390	808,197	774,965	933,860	836,605	1,297,182	706,576	6,048,700
9	11,781	13,955	12,473	11,243	9,656	10,882	9,916	9,799	89,705
10						4,553	18,279	45,394	68,226
11							5,791	39,913	45,704
12				18,803	24,614	18,710	11,954	17,796	91,877
13							1,884	2,632	4,516
14		3,747	40,665	271,430	650,293	1,174,963	4,859,253	7,679,588	14,679,939
15								3,303	3,303
16							424	684	1,108
17				2,388	151,405	127,128	170,241	112,029	563,191
18	922	2,879	3,149	3,131	2,399	2,090	2,616	3,087	20,273
19						2,997	18,753	27,770	49,520
20								8,406	8,406
21		14,000	104,783	73,465	78,937	123,302	205,305	427,017	1,026,809
22	11,768	107,814	412,870	378,552	437,432	656,092	984,660	727,099	3,752,204
23	103,413	745,885	723,011	431,379	453,745	609,127	517,878	490,954	4,116,771
24			73,994	635,942	1,021,886	1,270,408	1,488,033	1,348,019	5,838,282
25	252,493	374,000	681,648	586,322	385,964	311,552	246,418	190,272	5,401,602
26	4,084,710	4,491,742	4,525,109	3,692,707	3,677,837	5,049,609	4,788,443	4,908,919	126,907,182
27							3,815	294	4,109
28							986	10,952	11,938
29				8,511	88,031	97,267	78,198	87,908	359,915
30							1,839	4,455	6,294
31							1,612	1,108	2,720
32						12,490	95,027	83,072	190,589
33							4,637	5,843	10,480
34				1,685	1,000		1,793	938	5,416
35						28,541	104,436	68,304	201,281
36	3,812	3,779	63						18,372
37	317,598	390,024	428,000	302,979	347,057	411,156	510,749	608,753	7,732,524
38	3,589	4,000				5,642	4,552	5,026	34,942
39			753	541					1,294
40							195	9,516	9,711
41						388	198		586
42	1,032	108,057	836,137	1,825,048	2,908,756	3,525,114	4,006,259	2,266,778	15,477,181
43	65,916	429,972	3,305,788	5,401,224	7,375,674	7,965,705	8,190,191	6,503,484	39,237,954
44	33,469	35,187	279,466	2,758,382	1,946,630	1,244,545	1,023,179	620,337	7,972,427
45	13,068	10,279	15,028	13,436	24,588	216,915	881,429	686,853	1,861,596
46	1,241,114	2,166,600	2,888,040	2,409,890	3,172,426	3,567,034	4,897,851	2,989,527	23,882,059
47					12,416	36,211	41,778	28,242	118,647
48		278	2,219	2,254	564	14,575	49,759	33,700	103,349
49	2,054,499	2,170,094	2,015,861	1,305,957	1,289,709	1,158,917	1,464,455	847,697	23,249,302
50	197,888	130,798	115,744	97,413	83,954	303,869	955,941	596,840	2,787,296
51					5,919	47,281	202,960	319,988	576,148
52								2,785	2,785
53		1,361	27,771	125,348	177,418	981,971	2,612,959	1,430,618	5,357,446
54						1,849	19,173	14,747	35,769
55							1,077	33,819	34,896
56		9,506	314,024	2,801,645	5,934,151	10,976,744	13,013,979	9,510,913	42,560,962
57	10,232	21,423	16,632	13,308	4,540	3,401	11,952	6,731	121,976
58				1,011	504				1,515
59			1,000	6,337	10,021	6,578	5,212	1,937	31,085
60	6,892,342	6,740,520	5,774,319	5,132,948	5,209,467	4,984,291	4,727,414	4,813,575	104,280,309
61	1,197,640	2,292,854	2,522,897	2,207,771	1,860,577	1,707,303	1,451,603	1,450,102	16,389,658
62			8,112	21,254	17,825	16,256	14,811	16,801	95,059
63			51,683	381,846	762,010	494,987	355,167	278,191	2,323,884
64	18,328	14,701	9,945	6,276	5,707	5,009	3,676	360	140,811
65						563	689	832	2,084
66			84,892	121,329	89,014	79,563	62,536	58,716	496,050
67	695,725	604,648	525,913	457,636	403,009	393,554	397,484	337,850	8,911,640
68							1,195	2,353	3,548
69								986	986
70				595				259	854
71	328,635	319,980	308,476	267,008	231,805	260,554	239,447	222,998	9,405,687
72						5,650	191,285	735,255	932,190
73							14,292	78,330	92,622
74					22,884	42,043	89,328	110,244	264,499
75								16,093	16,093

TABLE 3.—(*Continued*)

	County, Field	Production Unallocated by Years	1922	1923	1924	1925
76	Fromme					
77	Grassroots					
78	Heiner					
79	Jamison & Pollard					
80	Lehn					
81	Masterson					
82	McKenzie					
83	Netterville					
84	Pecos Valley High Gravity					
85	Pecos Valley Low Gravity					
86	Richards					
87	Rowan Tong					
88	Shearer					
89	Taylor Link					
90	Tobarg					
91	Walker					
92	Wentz					
93	White and Baker					
94	Yates					
95	Yates Sand					
96	*Pecos and Ward:* Peyton					
97	*Reagan:* Barnhart					
98	Big Lake Shallow			19,110	1,060,793	8,889,518
99	Big Lake Deep					
100	Grayson					
101	*Reeves:* Anthony					
102	Toyah	5.250				
103	*Runnels:* Beddo					
104	Huddleston					
105	McMillan	603,108				
106	*Schleicher:* Opp					
107	Page					
108	*Scurry:* Sharon Ridge				8,255	5,981
109	*Tom Green:* Funk					
110	*Upton:* Herrington					
111	Hurdle					
112	McCamey					3,000
113	Webb Ray					
114	*Ward:* Byrd					
115	Dobbs					
116	Estes					
117	Magnolia Sealy					
118	Magnolia Sealy South					
119	Monahans					
120	Monahans Permian					
121	Monroe					
122	Nichols					
123	North Ward					
124	Pruitt					
125	Pyote					
126	Shipley					
127	Shipley Silurian					
128	South Ward					
129	Spencer					
130	Wilson					
131	*Winkler:* Eaves					
132	Emperor Deep					
133	Emperor Shallow					
134	Halley					
135	Henderson					
136	Hendrick					
137	Kermit					
138	Keystone					
139	Keystone Colby Sand					
140	Keystone Lime					
141	Leck					
142	Scharborough					
143	Weiner					
144	*Yoakum:* Ownby					
145	Waples Platter					
146	West					
147	Total	621,652	10,000	109,404	1,348,229	9,594,604

TABLE 3.—(*Continued*)

	1926	1927	1928	1929	1930	1931	1932	1933	1934
76									
77									
78									
79									
80									
81					7,964	1,883	620	2,015	15,908
82									
83									
84				10,475	46,085	50,362	82,936	66,545	23,797
85			1,275	30,317	23,724	16,874	17,517	11,787	20,300
86						5,530	6,333	7,475	1,490
87				1,526					
88									
89				518,167	1,488,704	531,309	321,118	238,073	376,276
90					463,799	591,544	502,207	454,702	425,141
91									
92									
93									
94	2,433	5,176,313	22,343,649	41,336,913	40,384,867	27,127,189	22,958,208	20,224,022	15,413,464
95								4,255	54,559
96									
97									
98	10,956,168	8,967,315	6,662,723	5,482,433	4,308,748	2,849,181	2,966,794	2,402,484	2,079,889
99			27,014	913,431	2,738,146	6,590,443	5,295,938	4,109,307	2,330,147
100			16,559	43,722	58,773	46,931	38,886	42,719	65,439
101									
102							500	250	400
103									
104									
105									
106									
107									
108	16,886	15,336	13,621	11,158	7,788	10,254	8,505	7,733	8,871
109									
110									
111									
112	1,750,396	6,910,218	4,387,749	3,234,654	2,650,054	1,636,309	1,321,972	1,281,237	1,330,410
113									
114									
115									
116								8,111	17,099
117						4,884	5,285	3,074	2,440
118									
119									
120									
121						2,350	12,484		3,733
122									
123				273,817	671,211	880,106	1,177,476	1,443,161	1,486,260
124									
125									
126			1,256	148,563	145,036	89,171	226,690	327,147	489,624
127									
128				15,782	92,290	272,008	501,402	921,860	1,581,891
129									
130									
131									
132									
133									
134									16,033
135									
136	6,431	3,647,862	57,577,158	48,885,250	25,472,142	14,549,772	10,135,661	7,301,884	6,254,760
137			7,163	137,925	276,370	183,671	139,378	119,516	115,196
138					6,389	10,421	5,141	5,048	3,896
139									
140									
141			161,330	828,318	513,552	428,922	280,881	222,594	196,594
142		1,180	1,238	199,480	180,414	181,641	206,886	489,560	804,549
143									
144									
145									
146									
147	14,972,745	52,106,958	119,150,967	132,924,716	107,959,284	77,370,518	62,479,308	53,920,013	48,125,657

TABLE 3.—(*Continued*)

	1935	1936	1937	1938	1939	1940	1941	1942	Total
76					9,093	28,215	34,401	22,382	94,091
77						469		270	739
78							3,828	2,124	5,952
79							21,200	27,247	48,447
80					23,572	132,504	134,733	91,139	381,948
81	26,713	193,415	290,420	173,473	90,208	65,501	58,531	46,860	973,511
82	1,518	929							2,447
83	3,336	62,542	91,662	82,971	53,256	40,562	30,098	23,980	388,407
84	49,778	69,000	77,000	147,379	334,480	276,690	239,696	190,438	1,664,661
85	23,904	53,000	86,000	102,885	131,549	201,707	184,368	110,148	1,015,355
86	3,524	1,200		300	1,195	798	920	1,406	30,171
87									1,526
88				72,163	463,570	288,653	204,218	182,707	1,211,311
89	426,466	429,590	409,833	463,666	536,753	616,785	699,883	608,617	7,665,240
90	632,488	777,366	772,297	614,077	608,695	569,170	518,730	479,037	7,409,253
91						11,987	150,208	244,009	406,204
92							1,538	22,128	23,666
93	1,831	1,123			34,437	59,470	70,504	84,785	252,150
94	15,197,819	12,214,156	10,558,488	6,728,427	7,737,871	6,861,864	5,605,546	6,640,318	266,511,547
95	75,585	96,846	71,868	43,981	37,280	38,140	44,375	38,659	505,548
96			1,804	291,292	1,092,641	687,446	473,242	326,180	2,872,605
97							14,378	103,096	117,474
98	1,942,926	1,946,852	1,771,435	1,573,938	1,586,261	1,471,734	1,385,281	1,288,862	69,612,445
99	1,584,094	925,769	874,332	798,099	689,342	602,705	566,882	539,015	28,584,664
100	64,749	59,100	58,243	44,513	38,041	30,072	21,402	17,254	646,403
101					1,437	674	391	22	2,524
102	100								6,500
103				511	3,490	19,937	28,179	46,013	98,130
104						5,592	7,066	2,093	14,751
105	194,004	83,159	y	32,410	22,562	17,173	3,647	2,006	958,069
106					1,865	730			2,595
107					10,361	12,520	9,677	7,859	40,417
108	11,671	12,199	12,930	13,436	77,492	279,719	415,598	419,727	1,357,160
109						300	60	351	711
110			11,284	24,703	17,195	11,776	10,401	9,685	85,044
111		13,918	64,768	56,939	37,462	30,049	21,951	16,863	241,950
112	2,066,449	3,029,548	4,324,000	5,158,761	4,665,587	3,986,877	3,509,361	3,196,900	54,443,482
113	1,331	12,809	17,135	8,278	10,014	8,785	5,894	3,972	68,218
114								7,844	7,844
115		5,197	3,679	2,510	2,200	2,034	2,325	2,083	20,028
116	49,944	309,063	3,153,931	2,449,431	2,307,454	2,463,394	1,945,822	1,467,118	14,171,367
117	2,733	1,000	1,000	45,852	154,780	238,352	321,763	226,851	1,008,014
118						6,757	81,618	167,750	256,125
119								33,608	33,608
120								5,830	5,830
121	8,275	9,155	8,106	8,266	6,344	6,206	8,690	5,953	79,562
122								1,041	1,041
123	2,090,760	3,129,614	3,187,321	2,075,963	2,077,072	2,164,081	2,403,965	2,018,546	25,079,353
124								1,552	1,552
125								22,375	22,375
126	621,221	597,377	609,211	476,750	440,435	481,944	563,198	444,405	5,662,028
127							22,123	12,447	34,570
128	3,451,296	4,951,000	5,570,509	3,480,928	2,292,231	1,717,704	1,314,729	975,197	27,138,827
129							9,419	43,435	52,854
130			1,919						1,919
131		2,000	58,000	108,761	100,650	122,449	158,796	154,017	704,673
132		10,000	102,000	143,725	172,544	189,089	170,753	116,715	904,826
133	16,368	284,000	385,000	317,011	321,699	339,829	424,186	374,694	2,462,787
134	57,829	73,042	208,830	165,801	135,615	101,137	118,208	83,497	959,992
135		217,673	1,239,157	1,022,825	861,229	980,413	876,548	1,126,109	6,323,954
136	5,723,412	4,790,595	4,348,250	4,046,916	3,326,736	2,952,753	2,814,056	2,512,225	204,345,863
137	755,594	2,947,000	6,818,000	5,683,705	4,787,212	3,179,647	2,847,376	1,698,582	29,696,335
138	98,398	527,000	1,206,000	1,232,564					3,094,857
139					742,758	982,216	1,186,435	1,248,940	4,160,349
140					621,773	667,399	557,555	454,079	2,300,806
141	181,397	160,478	176,961	127,924	110,980	165,075	195,605	154,709	3,905,320
142	801,214	649,682	663,960	580,867	577,435	546,542	598,927	457,861	6,941,436
143							1,450	81,707	83,157
144							25,415	46,073	71,488
145					9,244	14,396	17,804	22,318	63,762
146				6,139	8,392	10,652	9,058	8,348	42,589
147	54,325,488	60,702,823	74,664,104	71,545,697	78,071,298	83,286,523	92,381,343	81,225,917	1,276,897,248

TABLE 4.—*New Discoveries during 1942, Including New Pays in Established Fields*

	County	Field	Discovery Well	Total Depth, Ft.	Plugback Depth, Ft.	Producing Horizon	Gravity	Top of Pay, Ft.	Gas-oil Ratio
1	Andrews	Embar	Phillips Petr. Co. No. 2 University Andrews	7,855		Ellenburger	44.5	7,770	400[a]
2	Andrews	Embar Permian	Phillips Petr. Co. No. 9 University Andrews	8,174	6,275	Clear Fork	44	6,210	1,181
3	Andrews	Fullerton	Fullerton Oil Co. No. 1 Wilson	8,005		Wichita		7,250	364[a]
4	Andrews	Mascho	Wheelock & Cross No. 1 Sun University	4,514		San Andres		4,500	
5	Coke	Blackwell	W. F. Morgan No. 1 J. S. Craft	3,828		Cisco?	41.5	3,821	
6	Crane	McKee	Magnolia Petr. Co. No. 1 D. K. Glenn	6,186		Simpson	43.2	6,125	615
7	Ector	Undesignated	Oil Well Drilling Co. No. 1 Johnson	4,510	4,353	San Andres	33	4,210	10,864
8	Gaines	Robertson	Texas Company No. 1 J. B. Robertson	7,680	5,950	Clear Fork	25.5	5,910	350
9	Lubbock	Stinnett	Stanolind Oil & Gas Co. No. 1 J. F. Stinnett	7,000	5,372	Clear Fork	26.5	4,685	
10	Pecos	Wentz	Gulf Oil Corporation No. 3 L. H. Miller et al.	4,406		Cambrian Sand	38.8	4,376	227
11	Pecos	Chancellor	Pure Oil Co. 1—A G. C. Fraser	6,001	5,274	Delaware		5,250	
12	Pecos	Chancellor	Pure Oil Co. 1—Paul LeGros	5,072		Contact Castile-Delaware	38.5		1,372
13	Reagan	Big Lake	Big Lake Oil Co. No. 19-C University	4,383		San Angelo	42.2	4,310	574
14	Ward	Byrd	Stanolind Oil & Gas Co. No. 1 H. L. Byrd	2,885	2,679	Whitehorse	30	2,634	287
15	Ward	Monahans	Shell Oil Co. Inc. No. 1 Sealy Smith Foundation	10,545	10,364	Ellenburger	47	10,080	2,054
16	Ward	Monahans Permian	Shell Oil Co. Inc. No. 2 Sealy Smith Foundation	5,741	5,660	Clear Fork	34.5	5,635	1,369
17	Ward	Nichols	Cross Development Co. No. 1 C. A. Nichols	2,449		Whitehorse	35	2,400	225
18	Ward	Pruitt	Fred Heyer No. 1 T. B. Bruitt	4,869		Delaware		4,831	800
19	Ward	Pyote	Darby Petroleum Co. No. 1 University	2,847		Seven Rivers	19.3	2,827	

[a] Undersaturated.

contain errors which the writer has been unable to detect within the limited time available for this work. If such errors are called to our attention, corrections may be made in subsequent reports. In many cases, the information on gas production and reservoir pressures are based upon incomplete field data. In general, the best information is obtained from a field that has an engineering chairman, who gathers, compiles and coordinates the available data.

Table 3 gives estimated annual production. As some of the West Texas fields have changed names and boundaries since the discovery well was drilled therein, and as there is considerable variation in the reported production, dependent upon the source of the data, this table presents an interpretation of the readily available information. A more accurate table could be compiled from producers' production records.

Discoveries

This district is credited with 15 new discoveries (Table 4) during the year, of which 3 are producing from the Ordovician, 2 from the Pennsylvanian and 10 from the Permian. The author considers the most significant discoveries during the year to be the Fullerton, Embar and Monahans areas.

The Fullerton field was discovered in No. 1 H. M. Wilson well, Fullerton Oil Co., sec. 15, block A-32, P.S.L., Andrews County, which drilled to a depth of 8005 ft. and was plugged back to a depth of 7280. Pay was topped at 7045 ft. and the well flowed 682 bbl. of 43.1° gravity oil in 24 hr. after acid treatment. This well is significant in that it is the first well upon which complete information was available that is producing from the Tubb pay zone (Wichita) in the northern part of the Permian Basin. The possibilities for this "pay" occurring on many of our northern Texas Permian Basin and New Mexico structures are believed to be great.

The Embar discovery well was the No. 2 University, Phillips Petroleum Co., sec. 30, block 10, University survey, Andrews County. This well flowed 1422 bbl. of 44.5° gravity oil in 15 hr. naturally, from a depth of 7855 ft. Pay was topped at 7770 ft. Porosity is due to fracturing.

The Monahans discovery well was the No. 1 Sealy-Smith Foundation, Shell Oil Co., sec. 38, block G. & M. M. B. & A. survey, Ward County, which flowed 2852 bbl. of 46° gravity oil in 24 hr. after acid treatment, from a plugged-back depth of 10,364 feet. Pay was topped at 10,082 feet.

These two discoveries have many significant points in common. Both are producing from the Ellenburger (Lower Ordovician), and both areas have production in the Tubb pay zone. Both areas owe their discovery in a large part to geophysics. Both have shown possibilities in the Ordovician much farther north than heretofore explored. The possibilities opened up by these two discoveries are believed to be great.

Acknowledgments

The writer is particularly indebted to Mr. Taylor Cole, research geologist, University Lands, for preparing the part of the paper entitled "Discoveries." He desires to acknowledge also assistance and information obtained from the following persons: E. A. Wahlstrom and E. H. Griswold, Goldsmith Pool Engineering Committee; V. E. Cottingham, North Basin Pools Engineering Committee; C. D. Vertrees, Continental Oil Co.; Ross Carr and H. C. Stipp, Railroad Commission of Texas; S. S. Stinson and V. C. Maley, Humble Oil and Refining Co.; and J. M. Haygood, Humble Pipe Line Company.

Oil and Gas Production in West Central Texas in 1942

By M. G. Cheney,* Member A.I.M.E.

Careful estimates indicate that during 1942 new discoveries and extensions in West Central Texas added oil reserves slightly in excess of the eight million barrels produced. Drilling activity fell 40 per cent below 1941 and 82 per cent below the normal drilling activity of the late 1920's. Total production for the district continued its downward trend, now being less than ⅕ of the 42.7 million barrels peak in 1921. Rapid revival of activity is not probable under existing conditions, as costs of discovery, development and operations on the average probably now exceed current market price for the oil, the latter having remained constant since the spring of 1941. Costs have advanced materially since the third quarter of 1941, when reports to the Tariff Commission indicated a margin of profit of 13.3¢ per barrel.

Physical as well as economic conditions are holding back the amount of drilling in this district. The lenticular sands are not suited to 40-acre spacing regulations. There is no surplus of experienced oil-field labor. To reduce costs, much second-hand material is used for all except the deeper wells. Price controls have retarded movement of used equipment by prescribing maximum prices that are too low for the better grade material, thus making owners reluctant to sell. On the other hand, buyers are unwilling to pay ceiling prices asked by sellers for poor material.

Seventeen new oil fields and five new gas fields were found during 1942. Extensions and deeper drilling brought favorable results in eight older fields. The most significant new developments appear to have been in Coleman, Jones, Shackelford and Taylor Counties. A 5800-ft. completion in Wise County brought this county into the producing column for the first time. None of these new discoveries can be rated above one million barrel reserve on the basis of present development. Probably the most important development was discovery of a deeper pay (Gunsight lime) in the Wimberly field of Jones County, which shows promise of producing over an area of about 1000 acres. Jones and Shackelford Counties still lead the district in total annual production.

Discovery of the Reddin pool, north central Taylor County, is credited to geochemical methods, making one success out of five or more wildcats based on such methods. Geophysical surveying increased decidedly during 1942 and returns from these studies are expected during coming years. Most of the wildcatting in the district is still based on surface and subsurface geological structural mapping, study of log data as to distribution of prospective producing reservoirs, and drilling in proximity to previous showings of oil and gas.

Geological debate continues as to the proper correlation of the 100 to 300 ft. of gray lime that has produced more than 100 million barrels in the Parks, Breckenridge, Curry, Eliasville, Ibex, Pioneer and other important fields of this district. Fossils indicate that this limestone is younger than the Atoka beds of Oklahoma. On a structural basis most geologists include this formation with the Bend but a number of paleontologists believe it is more properly classified with the Strawn.

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TABLE 1.—*Oil and Gas Production in West Central Texas*

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
	Brown County					
1	Byler	1926	300		864,032	6,312
2	Byrd Store	1920	400		404,874	1,947
3	Childress	1927	300		905,854	22,329
4	Clark-Buffalo	1927	460		812,282	13,163
5	Cross Cut area	1921	2,300		6,491,266	72,183
6	Fry	1925	940		8,011,165	76,119
7	George	1927	200		906,426	42,471
8	Smith-Ellis	1926	450		2,425,354	43,835
9	Stover	1926	1,500		7,560,281	135,569
10	Others	1917	5,800		2,922,340	67,685
11	Total Brown County		12,650		31,303,874	461,613
	Callahan County					
12	Baum	1925	500		937,545	8,274
13	Hatchett	1927	375		1,480,055	30,388
14	Isenhour	1923	600		2,289,056	21,293
15	Moutray	1926	400		2,683,607	55,859
16	Scranton	1939	160		85,364	20,163
17	Others	1920	9,600		7,759,570	159,744
18	Total Callahan County		11,635		15,233,197	295,721
	Coleman County					
19	Anzac-Morris	1937	200		204,776	46,300
20	Burkett, shallow	1924	850		2,535,898	62,863
21	Burkett, deep	1930	160		722,141	9,258
22	Coker	1942	300		53,729	53,729
23	Dibrell-Gayle	1926	320		536,379	35,469
24	Eastland	1927	270		2,136,575	30,569
25	Goldsboro	1927	260		942,000	48,024
26	Jennings	1926	160		509,780	12,679
27	Jim Ned	1941	200		16,022	13,603
28	Novice	1927	1,000		886,109	272,629
29	Overall	1927	240		1,415,043	37,476
30	Santa Anna	1915	240	8,000	476,716	11,212
31	Silver Valley	1941	640		119,361	95,777
32	Stewardson	1929	240		475,183	17,093
33	Others	1910	1,000		1,270,608	40,931
34	Total Coleman County		6,080		12,191,260	787,612
	Comanche County					
35	Amity	1939			230,343	69,167
36	Sipe Springs	1919	800		1,700,000	15,108
37	Others	1918			881,247	10,454
38	Total Comanche County				1,811,590	94,729
	Comanche, Eastland County					
39	Desdemona	1918	6,200		23,641,842	138,942
	Eastland County					
40	Carbon	1939	200		75,707	13,807
41	Hilburn	1919	400		1,138,850	7,269
42	Mangum	1922	300		1,019,617	35,858
43	Pioneer	1919	1,400		5,661,613	50,987
44	Ransour	1926	250		1,560,452	25,651
45	Others	1917	28,000		66,390,128	543,364
46	Total Eastland County		40,550		75,846,187	676,936
	Fisher County					
47	Howard	1934	100		203,672	8,493
48	McCaulley	1941	200		63,989	46,173
49	Rotan	1936	640		1,323,802	113,366
50	Royston	1928	100		11,724,240	396,364
51	West Rotan	1937	80		67,351	7,189
52	Total Fisher County		3,920		13,383,054	571,585
	Haskell County					
53	Lawson	1942	40		3,317	3,317
54	Moody	1928	80		123,053	4,712
55	Pardue	1938	80		70,598	10,809
56	Others		10		12,072	
57	Total Haskell County		210		209,040	18,838
	Jones County					
58	Akard	1938	400		263,273	119,430
59	Appling	1939	80		65,800	9,891
60	Avoca	1935	640		2,101,084	329,759
61	Avoca, Griffin	1936	640		2,137,031	430,363
62	Avoca, North	1938	200		110,782	61,889
63	Avoca, West	1941	80		18,893	12,420
64	Dorsey, Hawley	1933	600		3,257,732	108,796
65	Guitar, Hawley	1936	400		823.821	27,335
66	Irvin, Noodle Creek	1937	500		402,676	95,364
67	Jennings-Lueders	1934	160		593,102	10,141
68	Lewis-Steffens	1936	1,500		2,492,231	361,397

[b] Footnotes to column heads and explanation of symbols are given on page 264.

TABLE 1.—(*Continued*)

Line Number	Number of Oil Wells End of 1942 Producing Oil[c]	Character of Oil Gravity A.P.I. at 60°F, Weighted Average	Producing Formation Name	Age[e]	Character[f]	Depth, Av. Ft. Top Prod. Zone	Bottoms Prod. Wells	Structure[h]
1	20	39	Fry	Pen	S		1,300	NL
2	10	37	Big Saline	Pen	L		2,450	A
3	59	35	Childress	Pen	S		800	AL
4	28	42	Fry	Pen	S		1,150	NL
5	132	40	Cross Cut	Pen	S		1,200	NL
6	91	42	Fry	Pen	S		1,300	NL
7	31	39	Fry	Pen	S		1,300	NL
8	35	41	Fry	Pen	S		1,300	NL
9	155	41	Blake	Pen	S		1,200	NL
10	292			Pen	SL	100	3,000	
11	853							
12	18	39	Cross Plains	Pen	S		1,780	NL
13	80	38	Moutray	Per	S		400	NL
14	119	37	Isenhour	Per Pen	S		700	NL
15	89	37	Moutray	Per	S		750	DL
16	8		Cathey	Pen	S		1,675	NL
17	820		Moran to Ellenburger	Per-Ord	SL	150	4,300	
18	1,134							
19	13		Morris-Cross Cut	Pen	S		2,100	NL
20	173	34	Burkett	Pen	S		400	NL
21	17	41	Cross Cut	Pen	S		1,550	NL
22	7	42	Morris	Pen	S		3,060	NL
23	18	42	Morris, Basal Big Saline	Pen	S-Cong.	1,900	3,200	NL
24	15	42	Up. Fry	Pen	S		2,000	NL
25	10	42	Gardner	Pen	S		3,875	AL
26	24	32	Jennings	Pen	S		1,200	NL
27	6	42	Morris-Gray	Pen	S		3,900	NL
28	49	41	Gardner	Pen	S		3,600	NL
29	15	42	Canyon-Strawn (5)	Pen	S		2,100	DL
30	10	39	Fry-Big Saline (Gas)	Pen	S		1,500	NL
31	12	43	Gray	Pen	S		3,600	NL
32	16	40	Fry-Gardner	Pen	S		1,450	NL
33	39		Pueblo to Ellenburger	Per to Ord	S-L	400	3,850	
34	424							
35	58	38	Blake	Pen	S		600	NL
36		39	Sipe Springs	Pen	S		350	NL
37			Strawn-Bend Ellenburger	Pen-Ord	S, L	300	4,000	
38	123							
39	58	40	Desdemona (Big Saline)	Pen	S		2,750	DL
40	13	40	Caddo Pool Black lime	Pen	L		2,600	NC
41	4	31	Big Saline	Pen	L		3,100	A
42	49	38	Strawn	Pen	S		1,200	NL
43	56	41	Pioneer (Parks)	Pen	L		2,450	AF
44	8	38	Big Saline	Pen	S		3,600	N
45	355		Strawn-Bend Ellenburger	Pen-Ord	S, L	900	4,100	N-A]
46	485							
47	2		Saddle Creek	Per	L		3,670	NC
48	7	42	Saddle Creek	Per	L		3,330	N
49	28	38	Camp Colorado	Per	L		3,500	N
50	101	39	Saddle Creek	Per	L		3,100	A
51	2	39	Camp Colorado	Per	L		3,600	NC
52	140							
53	1	40	Canyon	Pen	S		2,685	D
54	6	38	Hope	Pen	S		1,800	NL
55	3	39	Up Canyon	Pen	L		2,850	A
56	0							
57	10							
58	28	39	Bluff Creek	Per	S		2,150	A
59	3	36	King		S		2,640	NL
60	55	42	Palo Pinto	Pen	L		3,260	D
61	68	42	Palo Pinto	Pen	L		3,250	A
62	9	42	Palo Pinto	Pen	L		3,240	A
63	2	42	Palo Pinto	Pen	L		3,245	A
64	67	39	Pueblo Thrifty (6)	Per Pen	S, L	1,900	2,300	D
65	44	37	Thrifty	Pen	L		2,000	D
66	21	39	Camp Colorado, Upper Cisco (4)	Per Pen	L, S	2,350	3,000	A
67	13	39	King	Pen	S		2,040	A
68	178	38	Bluff Creek	Per	S		1,900	NL

TABLE 1.—(*Continued*)

Line Number	Field, *County*	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.	
			Oil	Gas[b]	To End of 1942	During 1942
69	Noodle Creek	1927	1,030		7,169,579	144,106
70	Noodle South	1941	160		68,602	38,544
71	Sandy Ridge-Higgs	1926	500		395,402	41,338
72	Sayles	1932	640		2,376,020	289,101
73	Stith	1940	100		25,858	14,537
74	Triplet	1940	160		67,022	25,665
75	Wimberly	1941	1,000		209,749	173,637
76	Others	1926	320		397,977	53,190
77	Total Jones County		9,050		22,977,084	2,347,351
	Palo Pinto County					
78	Strawn	1915	1,200		3,046,251	46,214
79	Others		1,500		2,122,229	52,552
80	Total Palo Pinto County		2,700		5,168,480	98,766
	Shackelford County					
81	Bluff Creek	1930	940		4,320,276	254,419
82	Cook	1925	1,500		17,753,734	562,634
83	Frye	1925	120		351,295	6,708
84	Hope	1923	220		1,491,513	62,673
85	Ibex	1921	1,240		2,484,375	19,373
86	Ivy	1937	900		1,876,681	316,828
87	Nail	1927	400		566,398	112,974
88	Newell	1924	640		953,372	40,505
89	Simmons-Harvey	1925	160		461,461	24,011
90	Tannehill-Mathews	1927	300		2,558,901	83,471
91	Others	1911	6,580		11,346,397	
92	Total Shackelford County		13,000		44,164,403	1,881,763
	Stephens County					
93	Curry	1921	2,600		9,851,169	97,219
94	Loving (Eolian)	1939	320		141,986	51.181
95	Strawn-Hohertz	1915	850		4,786,097	62,231
96	Stribling	1939	320		179,947	25,225
97	Others	1916	45,910		115,116,474	895,610
98	Total Stephens County		50,000		130,075,673	1,131,466
	Stonewall County					
99	Aspermont	1940	80		31,733	9,839
100	Boyd	1939	40		29,452	5,054
101	Carlisle	1938	80		103,171	18,443
102	Total Stonewall County		200		164,356	33,335
	Taylor County					
103	Bowles	1937	120		107,677	6,217
104	Merkel	1941	200		61,054	45,059
105	Reddin	1942	100		14,600	14,600
106	South View	1940	240		158,797	67,954
107	Trent	1942	80		9,936	9,936
108	Others	1929	320		435,764	36,612
109	Total Taylor County		1,060		784,879	180,429
	Throckmorton County					
110	McKnight	1941	160		28,017	16,136
111	Parrott	1941	80		9,097	7,989
112	Woodson (deep)	1929	320		1,942,045	36,899
113	Woodson (shallow)	1926	200		795,097	14,606
114	Others	1924	1,000		1,084,766	187,211
115	Total Throckmorton County		1,760		3,859,002	262,816
	Wise County					
116	Park Springs	1942	40		623	623
	Young County					
117	Anzac-Graham	1938	160		68,002	27,188
118	Briar Creek	1941	280		70,090	52,355
119	Bunger	1921	1,100		4,023,632	65,284
120	Burns-Larimore	1941	160		43,015	26,063
121	Burns-Ragland	1941	200		18,694	18,694
122	Graham	1926	400		1,792,294	23,740
123	Graham Vick	1930	320		859,528	57,454
124	Herron City	1921	640		1,638,616	25,254
125	James	1929	2,000		2,826,253	127,319
126	Kerlyn-Loving	1941	120		26,855	15,958
127	Kisinger	1929	400		1,136,793	42,593
128	Knight	1938	400		618,804	235,687
129	Knox	1939	1,000		546,128	111,082
130	Lupton-McLester	1936	500		551,000	85,974
131	Martin	1937	100		67,002	9,950
132	Padgitt	1942	120		27,220	27,220
133	Rathke	1932	400		2,149,174	186,793
134	Sewell	1938	1,200		797,916	315,805
135	Sinclair-Moren	1923	160		1,715,087	23,640
136	South Bend	1919	1,400		10,710,876	90,604
137	Williamson	1941	160		77,676	55,167
138	Others	1917	18,000		49,684,337	1,994,335
139	Total Young County				79,448,992	3,618,159

TABLE 1.—(*Continued*)

Line Number	Number of Oil Wells	Character of Oil	Producing Formation					
	End of 1942 Producing Oil[c]	Gravity A.P.I. at 60°F., Weighted Average	Name	Age[e]	Character[f]	Depth, Avg. Ft. Top Prod. Zone	Depth, Avg. Ft. Bottoms Prod. Wells	Structure[h]
69	68	38	Camp Colorado	Per	L		2,500	AC
70	6	44	Swastika	Pen	S		2,950	D
71	27	37	Bluff Creek	Per	S		1,900	NL
72	79	41	Cook	Pen	S		1,950	NL
73	4	42	Flippen Gunsight		S	2,350	2,670	D
74	5	36–42	Cook King	Per Pen		2,190	2,700	D
75	42	42	L. Wolfcamp Cisco (7)	Per Pen	S, L	2,100	3,300	
76	31		Wolf Camp Cisco Canyon	Pen	S, L			
77	750							
78	100		Strawn Big Saline	Per	S, L			NL
79	44		Strawn Bend	Per	S, L			
80	144							
81	262	37	Bluff Creek	Per	S		1,600	NL
82	388	37	Cook	Pen	S		300	ML
83	59	35	Frye	Per	S		450	NL
84	56	37	Hope	Pen	S		1,500	NL
85	20	39	Ibex	Pen	L		3,500	A
86	85	39	Cook, King, Palo Pinto	Pen	S, L	1,700	3,200	A
87	40	40	Bluff Ck., Cook	Per Pen	S		1,400	NL
88	84	37	Tannehill	Per	S		1,100	NL
89	20	39	Bluff Creek	Per	S		1,700	N
90	62	38	Tannehill	Per	S		1,150	NL
91	1,016		Wolfcamp to Ellenburger	Per-Ord	S-L	200	4,600	
92	2,093							
93	51	38	Up. Parks fm.	Pen	L		3,100	A
94	14	43	Up. Parks fm.	Pen	L		3,500	A
95	84	39	Strawn	Pen	S		1,850	MLN
96	13	42	Up. Parks-fm.	Pen	L		3,600	A
97	495		Strawn-Bend-Ellenburger	Penn-Ord	S-L	1,900	4,500	
98	657							
99	2	40	Miss-Strawn	Mis-Pen	L-S	6,060	5,150	A
100	1	39	Palo Pinto	Pen	L		4,725	A
101	2	41	Palo Pinto	Pen	L		5,175	AL
102	5							
103	8		Cook	Pen	S		1,750	NL
104	9	38	Dothan-L. Hope	Per-Pen	L	2,020	2,625	
105	4	40	Flippen-Hope	Pen	L	2,250	2,450	D
106	13	36	Flippen	Pen	L		2,400	D
107	2	42	Hope	Pen	L		2,770	
108	18		Wolf Camp-Canyon	Per-Pen				
109	54							
110	2	40	Parks	Pen	L		4,050	A
111	1	40	Parks	Pen	L		4,020	A
112	11	38	Parks	Pen	L		3,900	A
113	6	37	Canyon Strawn (3)	Pen	S	1,750	3,150	A
114	220		Cisco to Chappel	Pen-Mis	S, L	300	105	
115	240							
116	1	39	Big Saline	Pen	S		5,818	
117	3	40	Chappel-Eastland Lake-Strawn	Mis Pen	L-S	4,600	2,865	A
118	7	41	Parks-Chappel	Pen Mis	L	4,100	4,900	A
119	35	41	Strawn-Bend-(5)	Pen	S-L	1,900	4,250	AL
120	4	45	Chappel	Mis	L		4,925	D
121	5	41	Parks-Chappel	Pen-Mis	L	4,100	4,900	D
122	14	41	Strawn (2) Eastland Lake	Pen	S-L	2,100	3,850	D
123	20	40	Strawn (2)	Pen	S		2,650	AL
124	18	41	Strawn (4)	Pen	S	1,650	3,000	NL
125	59	42	Parks Eastland Lake-Big Saline.	Pen	L-S	3,850	4,300–4,400	A
126	3	41	Strawn Parks		S-L	3,400	4,075–4,265	A
127	24	41	Moren	Pen	S		2,550	L
128	32	41	Eastland Lake				3,800	A
129	28	40	Strawn Bend Miss	Pen Mis	S-L	2,750	4,000–4,760	A
130	21	41	Parks	Pen	S		3,700	NL
131	3	41	Strawn Parks Miss	Mis Pen	L-S	2,150	3,450–4,450	A
132	3	44		Mis	L		4,750	D
133	54	42	Strawn Eastland Lake-Big Saline	Pen	L-S	3,425	3,750–4,000	A
134	61	43	Eastland Lake	Pen	L		4,000	A
135	8	41	Moren	Pen	S		2,550	DL
136	73	40	Strawn (6) Bend (2) Chappel	Pen Mis	S-L	1,850	4,280	D-AL
137	4	42	Miss-Parks	Mis-Pen	L	5,050	4,000	A
138								
139	479							

Because of the large number and the localized occurrence of most of its producing reservoirs, this district doubtless will offer possibilities of successful wildcatting for many years to come. Accumulating data and closer study should continue to maintain a fairly favorable ratio of successful wildcat tests.

In the field of petroleum engineering the Cook pool of Shackelford County continues to demonstrate the effectiveness of well-administered gas drives. Past recoveries of more than 17 million barrels represent a yield of about 800 bbl. per acre-foot. Ultimate percentage recovery comparable to maximum expectations under an effective natural water drive is indicated by past yield and present slow decline. Artificial water drive projects are progressing favorably in several shallow sand fields of Throckmorton, Shackelford and Callahan Counties. It has been found that old wells relatively widely spaced may be used satisfactorily, thereby reducing flooding costs by about $\frac{2}{3}$ as compared with the orthodox Bradford methods. Restrictions imposed by proration have rendered more difficult the avoidance of excessive gas-oil ratios in gas-drive fields. Intermittent flow appears to be helpful in avoiding undersaturated conditions near the well. Apparently, as shown by laboratory tests,[1] permeabilities to gas rapidly increase and to oil greatly decrease upon a moderate lessening of oil saturation. Limiting daily flow to the period during which favorable gas-oil ratios prevail appears to be helpful in maintaining more favorable reservoir conditions.

In Young County, omitted in recent reports for North Texas and West Central Texas in these volumes, at least eight new fields and four new pays in older fields were found in 1942. Four of these new successes were from Mississippian limestone. The year's production from this county totalled 3,618,000 bbl., bringing cumulative total to almost 80,000,000 barrels.

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[1] H. G. Botset: *Trans.* A.I.M.E. (1940) **136**, 94, Fig. 3.

Oil and Gas Development in West Virginia during 1942

By David B. Reger,* Member A.I.M.E.

Wildcat drilling for new supplies of gas and the expansion of previously discovered oil and gas pools were the principal petroleum activities in West Virginia during 1942. Much of the new gas exploration is still uncompleted and still indecisive but various wildcats made substantial extensions to existing pools. Out of 53 wildcats drilled 27 resulted in commercial gas and 6 in commercial oil. Four of the oil discoveries also had commercial gas.

No strictly new pools of oil or gas can safely be described as discovered but several scattered oil and gas wells previously drilled have been confirmed as the openers of definite pools; also, various completions closed wide gaps between apparent gas pools already discovered. The proved oil territory of the state was increased about 4850 acres and the proved gas territory about 51,000 acres. The new proved oil reserves should about balance withdrawals and the new gas may represent a substantial increase.

Aside from the drilling in four rather lively pools, oil activity was slight because of unfavorable operating conditions and prices. Gas drilling also declined for reasons beyond the control of the operators. The account of operations, as gathered from trade journals and other reporting services, shows that 797 new wells were drilled, providing 119 new oil wells with 2762 bbl. of daily new production; 536 new gas wells with 1,228,501,000 cu. ft. of daily open flow; and 142 dry holes. Also, 76 old wells were drilled to deeper sands, with 71 bbl. and 26,034,000 cu. ft. of added production. On the new wells the oil average was 23.21 bbl. per well per day; and the gas average was 2,270,406 cu. ft. per well per day. On new wells the ratio of dry holes to completions was 17.82 per cent. On deeper drilling the ratio of failures was 21.05 per cent.

Production of oil for the year was estimated by the *Oil and Gas Journal* as 3,492,000 bbl., as compared with 3,378,000 bbl. in 1941.

Production of natural gas for the year is estimated by the author as 220,000,000,000 cu. ft., as compared with the U. S. Bureau of Mines final figures of 207,000,000,000 cu. ft.* in 1941.

General State of Industry

Leasing of wildcat acreage increased considerably. The total land of all classes under lease may now exceed 5,000,000 acres. Taking into consideration completions, abandonments and corrected figures or estimates, Table 1 shows cumulative and late annual statistics.

New Pools and Extensions

Table 2 shows the principal areas of drilling activity during 1942. Various consolidations of territory, hitherto treated as separate pools, have been made. In addition to these active pools, extensive drilling was done in numerous other areas where pool boundaries can hardly be defined.

Summary of Exploration

Table 3 gives a summary of important wildcat or exploratory wells drilled during

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* Consulting Geologist, Morgantown, W. Va.

* The Public Service Commission of West Virginia reports (by letter) 233,697,611,000 cu. ft.

1942, together with some others that have revealed unexpected deeper production in old fields.

DEVELOPMENT IN ORISKANY SAND

Drilling to the deep Oriskany sand (L. Dev.) increased in 1942, the total count showing 242 tests, of which 205 had commercial Oriskany gas. This sand furnished 86 per cent of the new gas discovered during the year. Virtually all of this Oriskany gas comes from the Charleston field of Jackson, Kanawha and Putnam Counties, where the field limit may not be greatly extended and where the proved area may be mostly drilled in the next two or three years. Of the 15 tests drilled outside of this field, only 2 had commercial Oriskany gas and the volumes of both were small (see Table 3 for these outside tests).

In the Charleston gas field, as summarized in Table 4, there was continued activity and several pools merged into the larger field. On the north it cannot extend much farther because of dry holes in Wood and Wirt Counties. On the east it is closely defined by about 20 dry holes, of which at least 15 have shown salt water. On the south it may extend to northern Boone County, where six small Oriskany wells have been drilled. On the west only one salt water well has appeared, but 10 or 12 wells showing tight or thinned-out sand seem to limit any wide extension. On the southwest a considerable amount of possible Oriskany territory yet remains to be explored in Loudon district, Kanawha County.

The total production of this field since discovery is reported as about 450 billion cu. ft. of which about 120 billion were taken out in 1942. Rock pressures now range from 200 to 1500 lb., depending on the production status of the locality. In the presently proved territory perhaps nearly one half of the available gas has now been recovered.

OPERATING TECHNOLOGY

No considerable changes or improvements in operating technique are reported for the year. Secondary recovery of oil, mostly by gas, or combined gas-air injection, continues to be used successfully in various old fields. A new gas repressuring project was started in a Gilmer County oil pool but will require several months to show definite results. Acidization of lime wells in Kanawha County and of lime gas wells in Raleigh County and elsewhere has been very successful. Underground storage of gas in depleted sands for peak winter use has been put into substantial practice. One company reports the successful operation of six projects in Pennsylvania and West Virginia, with two additional projects under test.

PIPE LINES, COMPRESSOR STATIONS AND MARKETS

Building of pipe lines has not been extensive during the year. In Gilmer County, the Pittsburgh and West Virginia

TABLE 1.—*Production Statistics, West Virginia*

Period	Oil		Average Oil per Well Daily, Bbl.	Gas		Average Gas per Well per Day, Cu. Ft.
	Number of Wells	Bbl. Produced		Number of Wells	Millions Cu. Ft. Produced	
To end of 1942		420,201,000			2,133,458	
During 1941	17,382	3,378,000[a]	0.53	13,878	207,681[b]	40,999
During 1942	17,051	3,492,000[a]	0.56	14,114	220,000[c]	42,705

[a] *Oil and Gas Journal*, estimate.
[b] U. S. Bureau of Mines, final figures.
[c] Author's estimate.

TABLE 2.—*New Pools and Extensions*

Pool (Oil or Gas), County and Producing Sand	Period	Wells, Initial Production and Proved Territory						
		Oil		Gas			Dry Holes	Proved Acres
		Number of Wells	Average Bbl. per Well per Day	Number of Wells	Average M Cu. Ft. per Well per Day	Average R.P.		
Bulltown (gas),[a] Braxton—B. I., 30-ft., G. Stray, Gord., Fifth	Before 1942	0		2	12,540[b]		3	900
	During 1942	0		4	353[b]	656	3	100
	Total	0		6	4,362[b]	616	6	1,000
Barboursville (gas), Cabell—Berea and B. shale	Before 1942	0		19			0	10,000
	During 1942	0		5	89	487	1	1,200
	Total	0		24	181	447	1	11,200
Sycamore (oil), Calhoun—B. I.	Before 1942	24		2			1	1,000
	During 1942	21	16.4	3	184	350	1	600
	Total	45		5			2	1,600
Morocco (gas), Clay—B. Lm., B. I.	Before 1942	0		7			1	500
	During 1942	0		4	1,285		0	500
	Total	0		11			1	1,000
Reed Fork (oil), Clay—B. I.	Before 1942	40?		0			0	1,000
	During 1942	9	3.6	0			0	0
	Total	49?		0			0	1,000
Villa Nova (gas), Braxton and Clay—Salt, Blue M., B. Lm., B. I.	Before 1942	2		54			30	4,500
	During 1942	0		17	543	472	7	7,500
	Total	2		71			37	12,000
Alice (oil), Gilmer—Maxton, B. Lm., B. I.	Before 1942	4		2	307		2	300
	During 1942	2	149	0			0	100
	Total	6		2			2	400
Charleston (gas field) (excluding Higginbotham Run oil pool), Jackson, Kanawha and Putnam—Oriskany	Before 1942	1	150	632	5,862	1,500?	44	107,000
	During 1942	0		203	5,195	1,400?	22	23,000
	Total	1		835	5,700	1,450?	66	130,000
Leroy (oil), Jackson—Berea	Before 1942	3		0			0	50
	During 1942	3	26	1			1	550
	Total	6	28	1	246		1	600
Eightmile Fork (gas), Kanawha—Squaw, Berea	Before 1942	0		3		473	0	100
	During 1942	0		2	187		0	50
	Total	0		5	203		0	150
Higginbotham Run (oil), Kanawha—B. Lm.	Before 1942	7		0			1	100
	During 1942	13	124	2	1,033		5	100
	Total	20		2	1,033		6	200
Griffithsville (oil), Lincoln—Berea	Before 1942	400?						9,000
	During 1942	5	9.4				0	3,000
	Total	405?						12,000
Spurlockville (gas), Lincoln—Berea, B. shale	Before 1942	0		38+	357	403	4+	19,000
	During 1942	0		17	497	383	0	0
	Total	0		55+	400	398	4+	19,000
Maxwell (gas and oil), Pleasants—Salt, Maxton, Keener, B. I., Squaw	Before 1942	2	5	6	234	440	3	300
	During 1942	1	6				0	100
	Total	3	5	6	234	440	3	400
Trace Fork (gas), Putnam—Salt, B. Lm., Berea, Brown shale	Before 1942	1		64	864	521	4	12,000
	During 1942	0		40	310	483	1	13,000
	Total	1		104	414	500	5	25,000
Slab Fork (gas), Raleigh—Stony Gap, Maxton, B. Lm.	Before 1942	0		6			1	800
	During 1942	0		4			0	200
	Total	0		10	857	515	1	1,000
Lost Run (gas), Taylor—B. I.	Before 1942	0		5	242	250	2	100
	During 1942	0		3	205	233	2	600
	Total	0		8	226	240	4	700
Lorentz (gas), Upshur—50-ft. Gord., Fifth, Benson	Before 1942	0		14	297	1,203	3	2,000
	During 1942	0		8	529	1,054	0	2,500
	Total	0		22	400	1,119	3	4,500
Rock Cave (gas), Upshur—B. I., Squaw, Gord., Benson	Before 1942	0		5	243	364	0	1,000
	During 1942	0		7	600	381	0	200
	Total	0		12	451	377	0	1,200
Evergreen (gas), Upshur—Gord., Fifth, Riley, Benson	Before 1942	0		23			5	3,500
	During 1942	0		12	566	515	4	1,000
	Total	0	0	35			9	4,500
Crum (gas), Wayne—Salt, B. Lm., B. I.	Before 1942	1	2	6			4	1,000
	During 1942	0		2			0	0
	Total	1	2	6	1,671	509	4	1,000
Ogdin (oil), Wood—Cow Run, Berea	Before 1942	25?	25?	?			?	1,000
	During 1942	2	5	1	134	280	1	500
	Total	27?		?			?	1,500

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[a] Abbreviations as follows: B. I., Big Injun; B. Lm., Big Lime; Blue M., Blue Monday; B. shale, Brown shale; 50-ft., Fifty-foot sand; Gord., Gordon; G. Stray, Gordon Stray; 30-ft., Thirty-foot sand.

[b] Includes a 1914 wildcat of 25,000 M cu. ft., which soon exhausted.

TABLE 3.—*Important Wildcats Drilled in West Virginia during* 1942

Line No.	County	Magisterial District	Location		Total Depth, Ft.	Surface Formation
			Lat.	Long.		
1	Boone	Crook	4.37 mi. S. of 38°05′	3.26 mi. W. of 81°40′	5,373	Pen-Kanawha
2	Braxton	Birch	1.18 mi. S. of 38°35′	3.52 mi. W. of 80°45′	2,523	Pen-Kanawha
3	Braxton	Birch	1.78 mi. S. of 38°35′	4.43 mi. W. of 80°45′	2,340	Pen-Conemaugh
4	Braxton	Otter	1.86 mi. S. of 38°40′	2.41 mi. W. of 80°40′	2,735	Pen-Conemaugh
5	Braxton	Salt Lick	0.46 mi. S. of 38°50′	2.02 mi. W. of 80°30′	2,093	Pen-Conemaugh
6	Clay	Buffalo	4.64 mi. S. of 38°35′	3.70 mi. W. of 80°55′	2,208	Pen-Conemaugh
7	Clay	Buffalo	0.55 mi. S. of 38°30′	0.44 mi. W. of 81°00′	2,229	Pen-Conemaugh
8	Clay	Henry	1.92 mi. S. of 38°30′	1.94 mi. W. of 80°05′	2,076	Pen-Allegheny
9	Clay	Henry	1.42 mi. S. of 38°30′	1.72 mi. W. of 81°00′	2,234	Pen-Conemaugh
10	Gilmer	Troy	4.51 mi. S. of 39°05′	3.30 mi. W. of 80°45′	1,648	Pen-Monongahela
11	Gilmer	Troy	4.65 mi. S. of 39°05′	3.38 mi. W. of 80°45	1,720	Pen-Monongahela
12	Hancock	Clay	3.40 mi. S. of 40°35′	0.94 mi. W. of 80°35′	4,829	Pen-Conemaugh
13	Harrison	Eagle	3.80 mi. S. of 39°30′	1.48 mi. W. of 80°20′	6,900	Pen-Monongahela
14	Jackson	Ravenswood	3.75 mi. S. of 38°55′	0.50 mi. W. of 81°35′	5,250	Perm-Dunkard
15	Jackson	Ravenswood	1.54 mi. S. of 38°55′	3.14 mi. W. of 81°30′	2,660	Perm-Dunkard
16	Jackson	Ripley	4.14 mi. S. of 38°55′	3.67 mi. W. of 81°35′	5,187	Perm-Dunkard
17	Jackson	Ripley	4.29 mi. S. of 38°50′	3.68 mi. W. of 81°35′	4,977	Perm-Dunkard
18	Jackson	Ripley	0.86 mi. S. of 38°40′	2.62 mi. W. of 81°40′	5,208	Perm-Dunkard
19	Jackson	Ripley	4.85 mi. S. of 38°50′	0.49 mi. W. of 81°40′	5,298	Perm-Dunkard
20	Jackson	Ripley	5.25 mi. S. of 38°45′	2.10 mi. W. of 81°40′	5,291	Perm-Dunkard
21	Jackson	Washington	2.60 mi. S. of 38°50′	2.01 mi. W. of 81°35′	5,251	Perm-Dunkard
22	Jackson	Washington	3.40 mi. S. of 38°50′	2.42 mi. W. of 81°35′	5,247	Perm-Dunkard
23	Kanawha	Cabin Creek	2.42 mi. S. of 38°10′	0.50 mi. W. of 81°20′	2,952	Pen-Kanawha
24	Kanawha	Poca	5.65 mi. S. of 38°40′	4.34 mi. W. of 81°40′	5,195	Perm-Dunkard
25	Kanawha	Union	3.60 mi. S. of 38°30′	2.12 mi. W. of 81°40′	4,911	Pen-Conemaugh
26	Kanawha	Union	4.57 mi. S. of 38°35′	3.18 mi. W. of 81°40′	4,756	Pen-Conemaugh
27	Kanawha	Union	1.32 mi. S. of 38°30′	2.14 mi. W. of 81°40′	1,598	Pen-Conemaugh
28	Lewis	Collins Settlement	2.76 mi. S. of 38°55′	4.19 mi. W. of80°20′	2,290	Pen-Conemaugh
29	Lincoln	Duval	4.51 mi. S. of 38°20′	3.15 mi. W. of 81°50′	4,327	Pen-Conemaugh
30	Lincoln	Duval	3.25 mi. S. of 38°20′	3.80 mi. W. of 81°50′	2,425	Pen-Conemaugh
31	Lincoln	Washington	3.00 mi. S. of 38°20′	0.77 mi. W. of 81°50′	4,840	Pen-Conemaugh
32	Logan	Logan	4.95 mi. S. of 37°55′	0.87 mi. W. of 82°00′	2,433	Pen-Kanawha
33	Marshall	Franklin	0.03 mi. S. of 39°45′	0.88 mi. W. of 80°50′	6,843	Perm-Dunkard
34	Marshall	Franklin	0.06 mi. S. of 39°45′	0.92 mi. W. of 80°50′	6,875	Perm-Dunkard
35	Mason	Arbuckle	0.89 mi. S. of 38°45′	3.40 mi. W. of 81°55′	4,000	Pen-Monongahela
36	Putnam	Pocatalico	4.58 mi. S. of 38°35′	3.28 mi. W. of 81°45′		Pen-Conemaugh
37	Putnam	Pocatalico	4.25 mi. S. of 38°35′	1.67 mi. W. of 81°45′	1,690	Pen-Conemaugh
38	Putnam	Union	4.25 mi. S. of 38°40′	0.12 mi. W. of 81°45′	5,278	Perm-Dunkard
39	Raleigh	Richmond	2.44 mi. S. of 37°45′	1.76 mi. W. of 81°00′	4,760	Pen-New River
40	Ritchie	Grant	4.54 mi. S. of 39°20′	1.21 mi. W. of 81°10′	7,315	Perm-Dunkard
41	Ritchie	Grant	0.04 mi. S. of 39°10′	0.72 mi. W. of 81°10′	1,985	Perm-Dunkard

TABLE 3.—(*Continued*)

Line No.	Deepest Horizon Tested	Drilled by	Property and Well No.	Initial Production per Day		Tubing or Casing Pressure, Lb. per Sq. In.	Remarks
				Oil, Bbl.	Gas, Millions Cu. Ft.		
1	L. Dev-Oriskany	Pond Fork Oil & Gas Co.	Pond Fork Coal Co., 20-62	0	0.300	250 (8 hr.)	Big Lime and Shale gas well. Dry in Oriskany
2	U. Dev-Catskill	Pittsburgh & W. Va. Gas Co.	W. H. Herold, 1-7822	0	0	0	Dry through Fifth
3	L. Mis-Pocono	Pittsburgh & W. Va. Gas Co.	Ellet Cart, 1-7861	0	0	0	Dry through Big Injun
4	U. Dev-Catskill	Hamilton Gas Corp.	Vena Floyd, 1-J-1	0	0	0	Dry through Bayard
5	U. Dev-Catskill	Pittsburgh & W. Va. Gas Co.	W. T. Brown, 1-7821	0	0.031	355 (48 hr.)	Big Injun gas well
6	L. Mis-Pocono	Pittsburgh & W. Va. Gas Co.	Elk River C. & L. Co., 10-7823	0	0.240	487 (72 hr.)	Big Injun gas well
7	L. Mis-Pocono	Pittsburgh & W. Va. Gas Co.	Elk River C. & L. Co., 13-7851	0	0.820	502 (90 hr.)	Big Injun gas well
8	L. Mis-Pocono	Thompson Gas Co.	Samuel King, 1-T55	0	0.076	262 (48 hr.)	Big Injun gas well
9	L. Mis-Pocono	Thompson Gas Co.	J. A. Sizemore, 1-T60	0	0	0	Dry through Big Injun
10	U.Mis-Mauch Chunk	A. M. Cooper	H. E. & T. F. Bush, 1	48	0.116		Maxton oil and gas well
11	L. Mis-Pocono	A. M. Cooper	H. E. Bush, 1	250	0.413	550 (1 hr.)	Big Injun oil and gas well
12	L. Dev-Oriskany	John T. Galey	Lenora Ramsey, 1	0	0.365		Oriskany gas well
13	M. Dev-Hamilton	Lumberport-Shinnston Gas Co.	E. E. Heldreth, 1	0	Small		Reported small gas in unknown sand
14	L. Dev-Oriskany	Columbian Carbon Co.	F. F. Battis, 1-GW669	0	0	0	Dry through Oriskany (salt water)
15	L. Mis-Pocono	Columbian Carbon Co.	Henry Wallbrown, 1-GW673	2	0	0	Berea oil well
16	L. Dev-Oriskany	United Carbon Co.	G. L. Cabot, Inc., 1-931	0	9.622	1,755 (24 hr.)	Oriskany gas well
17	L. Dev-Oriskany	Spartan Gas Co.	N.S.Thomas Hr.,1-S-28	0	6.564	1,875 (48 hr.)	Oriskany gas well
18	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	J. L. McLean Hr., 17-1038	0	8.023	1,750 (48 hr.)	Oriskany gas well
19	L. Dev-Oriskany	Howard Bartlett	Sattis Simmons, 1	0	0.026	0	Dry through Oriskany
20	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	J. L. McLean Hr., 20-1059	0	0.504		Oriskany gas well
21	L. Dev-Oriskany	Hope Nat. Gas Co.	B. M. Pfost, 1-8585	0	6.472	1,830 (24 hr.)	Oriskany gas well
22	L. Dev.-Oriskany	United Fuel Gas Co.	L. E. Young, 1-5085	0	10.067		Oriskany gas well
23	L. Mis-Pocono	Godfrey L. Cabot, Inc.	Angus McDonald, 1-1053	0	0	0	Dry through Berea
24	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	J. L. McLean Hr., 16-1034	0	0.776	1,300 (24 hr.)	Oriskany gas well
25	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	Adam Burford, 1-1039	0	0.636		Oriskany gas well
26	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	J. L. McLean Hr., 22-1057	0	0.783	1,485 (90 hr.)	Oriskany gas well
27	L. Mis-Greenbrier	Godfrey L. Cabot, Inc.	W. H. O'Dell, 1-1073	0	3.499	560 (16 hr.)	Big Lime gas well
28	U. Dev-Catskill	Mudlick Oil & Gas Co.	Nicholas Strader, 1-116	0	0	0	Dry through Gordon
29	M. Dev-Marcellus	Mary Lou Gas Co.	Stewart & Hager, 1-1	2	0.014		Berea oil well
30	L. Mis-Pocono	Cambridge Gas Co.	O. E. Esque, 1	4	0.060		Berea oil and gas well
31	L. Dev-Oriskany	Owens-Libbey-Owens	Lincoln Land & Mineral Co., 1-646	0	0.034	110	Brown Shale gas well. Dry in Oriskany
32	L. Mis-Pocono	O. B. Cunningham	Workman & Mullins, 1	0	0.035		Berea gas well
33	Sil-Salina	Pittsburgh Plate Glass Co.	Defense Plant Corp., 1	0	0	0	Salina (Sil) brine well; rock salt 6,725–6,838; no oil or gas
34	Sil-Salina	Pittsburgh Plate Glass Co.	Defense Plant Corp., 2	0	0	0	Salina (Sil) brine well; rock salt 6,785–6,865; no oil or gas
35	M. Dev-Marcellus	Guy B. Ray	Guy B. Ray, 1	0	0.009	150 (72 hr.)	Brown shale gas well
36	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	Hatfield Campbells Creek Coal Co., 1-1041	0	0	0	Dry through Oriskany
37	L. Mis-Greenbrier	Godfrey L. Cabot, Inc.	Black Betsey Coal Co., 1-1067	0	0.232	750	Big Lime gas well
38	L. Dev-Oriskany	Godfrey L. Cabot, Inc.	Eva Carney, 1-1075	0	1.400		Oriskany gas well
39	U. Dev-Chemung	Godfrey L. Cabot, Inc.	Grace Land Co., 1-1031	0	0	0	Dry through Benson
40	Sil-Salina	Benedum-Trees Oil Co.	L. J. Rinehart, 1	15	0	0	Maxton oil well; otherwise dry through Newburg. Salina (Sil) rock salt, 6,529–6,576
41	L. Mis-Pocono	South Penn Nat. Gas Co.	Mike Foy Hr., 2	0	1.917	600 (96 hr.)	Big Injun gas well

TABLE 3.—(*Continued*)

Line No.	County	Magisterial District	Location		Total Depth, Ft.	Surface Formation
			Lat.	Long.		
42	Roane	Reedy	4.32 mi. S. of 38°55′	3.35 mi. W. of 81°20′	2,700	Perm-Dunkard
43	Tyler	Meade	5.02 mi. S. of 39°30′	0.98 mi. W. of 81°00′	6,400	Perm-Dunkard
44	Upshur	Banks	3.81 mi. S. of 38°55′	0.80 mi. W. of 80°20′	4,417	Pen-Conemaugh
45	Upshur	Meade	0.39 mi. S. of 38°50′	2.85 mi. W. of 80°10′	4,636	Pen-Conemaugh
46	Upshur	Meade	5.10 mi. S. of 38°55′	0.52 mi. W. of 80°15′	2,100	Pen-Kanawha
47	Wayne	Union	3.26 mi. S. of 38°20′	3.58 mi. W. of 82°25′	4,000	Pen-Conemaugh
48	Wayne	Union	0.96 mi. S. of 38°20′	0.62 mi. W. of 82°25′	4,040	Pen-Conemaugh
49	Wirt	Spring Creek	0.38 mi. S. of 38°55′	1.60 mi. W. of 81°20′	5,670	Perm-Dunkard
50	Wood	Clay	0.54 mi. S. of 39°15′	3.58 mi. W. of 81°25′	2,400	Perm-Dunkard
51	Wood	Lubeck	2.13 mi. S. of 39°15′	0.47 mi. W. of 81°40′	1,375	Perm-Dunkard
52	Wood	Steele	4.15 mi. S. of 39°10′	2.69 mi. W. of 81°30′	4,861	Perm-Dunkard
53	Wyoming	Center	3.67 mi. S. of 37°40′	2.30 mi. W. of 81°30′		Pen-New River

Line No.	Deepest Horizon Tested	Drilled by	Property and Well No.	Initial Production per Day		Tubing or Casing Pressure, Lb. per Sq. In.	Remarks
				Oil, Bbl.	Gas, Millions Cu. Ft.		
42	L. Mis-Pocono	Benedum-Trees Oil Co.	H. E. Criner, 1	0	0	0	Dry through Berea
43	L. Dev-Oriskany	Benedum-Trees Oil Co.	Pearl Broadwater, 1	0	0	0	Dry through Oriskany
44	U. Dev-Chemung	Hanley & Bird	Lon Ogden, 1-984	0	0.075	1,090	Benson gas well
45	U. Dev-Chemung	Hanley & Bird	Morrison & Sexton, 1-978	0	0	0	Dry through Benson
46	U. Dev-Catskill	Earl Goodwin	Brown & Bean, 1	0	0	0	Dry through Bayard
47	Sil-Niagara	Owens-Libbey-Owens	Minnie R. Ealem, 1-644	0	0.070	1,310 (12 hr.)	Newburg gas well
48	Sil-Niagara	Owens-Libbey-Owens	J. P. Barbour, 1-645	0	0.133		Newburg gas well
49	L. Dev-Oriskany	Benedum-Trees Oil Co.	Park Smith, 1	0	0	0	Dry through Oriskany (salt water)
50	L. Mis-Pocono	South Penn Nat. Gas Co.	Annie McPherson, 1	0	0	0	Dry through Berea
51	Pen-Pottsville	South Penn Nat. Gas Co.	W. R. Bigelow, 1	0	1.400	415	Salt gas well
52	L. Dev-Oriskany	Glen W. Roberts	I. B. Robinson, et al, 1-34	0	0	0	Dry through Oriskany
53	L. Mis-Greenbrier	Godfrey L. Cabot, Inc.	C. C. Sharp, 1-1046	0	0.582		Big Lime gas well

Gas Co. built 9 miles of 12-in. gas line, starting at the Waldeck farm, 9 miles east of Cedarville and extending north to the Floyd farm 8 or 9 miles east of Glenville.

In Braxton County the same company built 2 miles of 10-in. gas line starting near the mouth of Twomile Fork of Steer Creek 2 miles southeast of Rosedale and extending northeastward to the Bollinger farm on O'Brien Fork.

In Clay County the same company laid 4 miles of 12-in. and ½ mile of 8-in. gas line starting at Villa Nova (Duck P. O.) and extending south to Paddy's Ridge. The same company laid about 5 miles of 6-in. gas line near Vadis (Lewis County) and West Union (Doddridge County). The same company has under construction and about 80 per cent complete a 1200-hp. gas-compressor station at the mouth of

Twomile Fork, 2 miles southeast of Rosedale, Braxton County.

In Jackson County, Columbian Carbon Co. completed its Goldtown 1600-hp. gas-compressor station at Goldtown, 6 miles north of Sissonville.

In Marshall County the 24-in. oil pipe line of the Defense Plant Corporation, now building from Illinois to the Atlantic seaboard, will cross the Ohio River near Powhatan Point and pass out of the state near Rock Lick.

The price of oil has again increased slightly during the year. From Aug. 23, 1941 until March 26, 1942 the price stood at $2.34 per bbl. On the latter date it was increased to $2.59 and so remained. The price of gas at the well mouth, estimated by the U. S. Bureau of Mines as 12.3¢ per M cu. ft. in the year 1940 declined to 12.1¢ in 1941. Figures are not available for 1942, but there has been little change.

County Summary

Table 5 shows by counties the new development in West Virginia during 1942. This information is compiled from all available sources, including the trade journals, the West Virginia Department of Mines, the West Virginia Geological Survey, the special Plat Service offered by Veleair C. Smith, Management, and from private reports.

The various reports do not altogether agree, but Table 5 attempts to reflect a careful history of every well that was completed in the state in 1942.

According to the Department of Mines, 870 permits to drill were issued as compared with 1078 in 1941. Of the permits 758 wells had been reported to the Department as completed at the end of the year. The records of numerous other wells, available through weekly trade journals, etc., but not yet certified to the Department, largely

Table 4.—*Oriskany-sand Wells, Jackson and Kanawha Counties and Adjacent Part of Putnam County, West Virginia*

County and Magisterial District	Completed before 1942				Completed in 1942				Total Number of Completed Wells	Number of Wells Drilling or Unreported Jan. 1, 1943
	Gas Wells		Dry in Oriskany	Total Number of Wells	Gas Wells		Dry in Oriskany	Total Number of Wells		
	Number of Wells	Gas M Cu. Ft.			Number of Wells	Gas, M Cu. Ft.				
Jackson County										
Grant	2	717	0	2	1	112	0	1	3	0
Ravenswood	32	175,944	3	35	23	104,059	6	29	64	8
Ripley	85	483,606	3	88	102	605,982	3	105	193	32
Washington	31	222,619	3	34	24	191,133	6	30	64	13
Total	150	882,886	9	159	150	901,286	15	165	324	53
Kanawha County										
Big Sandy	0	0	1	1	0	0	0	0	1	0
Cabin Creek	0	0	3	3	0	0	0	0	3	0
Charleston	1	88	0	1	0	0	0	0	1	0
Elk	91	375,356	12	103	1	855	1	2	105	0
Jefferson	0	0	1	1	0	0	0	0	1	0
Loudon	8	3,788	5	13	0	0	0	0	13	0
Malden	35	73,181	5	40	0	0	0	0	40	0
Poca	327	2,334,322	3	330	41	138,733	4	45	375	12
Union	17	33,878	2	19	4	7,129	1	5	24	6
Washington	1	254	3	4	0	0	0	0	4	0
Total	480	2,820,867	35	515	46	146,717	6	52	566	18
Putnam County										
Union	2	1,588	0	2	7	6,588	1	8	10	3
Grand total	632	3,705,341	44	676	203	1,054,591	22	225	900	74

account for the discrepancies of Table 5 as compared with Department figures.

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TABLE 5.—*Summary of New Development in West Virginia during* 1941

County	New Wells						Wells Drilled to Deeper Sands			
	No. of Wells	Oil Wells		Gas Wells		Dry Holes	No. of Wells	Production		Dry Holes
		No. of Wells	Bbl. per Day	No. of Wells	M Cu. Ft. per Day			Oil, Bbl. per Day	Gas, M Cu. Ft. per Day	
Barbour	1	0	0	1	492	0	0	0	0	0
Boone	39	5	24	30	7,436	4	1	0	0	1
Braxton	23	1	15	14	7,089	8	5	0	1,439	2
Brooke	3	3	15	0	0	0	0	0	0	0
Cabell	6	0	0	5	447	1	0	0	0	0
Calhoun	74	32	395	29	17,357	13	5	50	153	2
Clay	48	9	33	28	21,383	11	2	0	253	1
Doddridge	6	2	10	3	554	1	2	0	509	0
Gilmer	41	3	303	26	19,612	12	2	0	327	1
Hancock	5	3	2	2	140	0	0	0	0	0
Harrison	8	1	6	7	610	0	4	0	280	0
Jackson	171	4	93	150	915,386	17	4	0	5,946	1
Kanawha	90	16	1,620	59	152,734	15	8	16	7,740	2
Lewis	8	3	11	4	2,693	1	1	0	900	0
Lincoln	19	5	47	13	6,231	1	24	0	7,415	0
Logan	8	0	0	7	3,140	1	0	0	0	0
Marion	7	4	21	3	1,110	0	1	0	0	1
Marshall	11	0	0	6	1,836	5	1	0	86	0
Mason	3	0	0	1	9	2	0	0	0	0
Mingo	5	1	3	4	1,155	0	0	0	0	0
Monongalia	7	0	0	4	661	3	5	0	412	1
Nicholas	1	0	0	1	340	0	0	0	0	0
Pleasants	4	1	6	1	182	2	0	0	0	0
Putnam	54	0	0	48	17,888	6	2	3	250	0
Raleigh	5	0	0	4	6,714	1	0	0	0	0
Ritchie	38	6	37	18	9,068	14	3	0	240	0
Roane	11	5	29	1	54	5	1	0	0	1
Taylor	7	0	0	5	1,008	2	0	0	0	0
Tyler	6	4	29	1	231	1	0	0	0	0
Upshur	37	0	0	33	16,890	4	0	0	0	0
Wayne	15	1	2	14	8,251	0	0	0	0	0
Wetzel	10	0	0	7	4,874	3	3	0	49	2
Wirt	8	2	6	2	547	4	1	2	35	0
Wood	15	8	55	3	1,750	4	1	0	0	1
Wyoming	3	0	0	2	709	1	0	0	0	0
State total	797	119	2,762	536	1,228,501	142	76	71	26,034	16

Petroleum Development in Argentina during 1942

By Mario L. Villa*

Oil activities and the petroleum industry in general have suffered severely in this country as a result of present war conditions. War has imposed a very heavy and unpleasant burden on the shoulders of those whose duty it is to keep Argentina supplied with the necessary oil to meet industry's growing demands.

Since 1940, imports of manufactured products from Europe and the United States have fallen to a minimum, making it necessary to manufacture as many of them as possible locally. This has brought about the establishment of many new industries and the enlargement of already existing plants, creating new demands for fuel that drain heavily the country's stocks, which already were overtaxed because of the diminished supply imported.

To cope with this problem, a plan for an intensification of oil-field activities was drawn up by Yacimientos Petrolíferos Fiscales (Argentine Government Oil Fields) which included the drilling of many new

Table 1.—*Oil and Gas Production in Argentina*

Line No.	Field, Territory or Province	Year of Discovery	Area Proved, Acres	Total Oil Production, Bbl.		Total Gas Production, Millions Cu. Ft.	
			Oil and Gas[b]	End of 1941	During 1942	To End of 1941	During 1942
	Comodoro Rivadavia, *Chubut*						
1	Zone A—Costa	1907	13,150	111,377,379	4,430,840	178,089	7,695
2	Zone B—Escalante	1924	17,650	65,204,313	7,052,094	44,902	6,001
3	Zone C—Astra	1916	4,695	19,389,428	1,053,322	12,108	634
4	Zone D—Campamento Sud	1919	190	479,643	73,340	141	106
5	Zone E—Col. Sarmiento	1933	13	24,406			
6	Zone F—El Trébol	1937	10,225	6,140,975	3,609,509	706	918
	Plaza Huincul, *Neuquên*						
7	Zone 1—Centro Octógono	1918	140	1,733,225	36,143	2,153	32
8	Zone 2—Oesta Octógono	1926	1,790	5,790,305	951,269	13,266	3,809
9	Zone 3—Laguna Colorada	1924	508	10,134,419	226,668	10,308	301
10	Zone 4—Bajo Los Baguales	1934	58	44,749			
11	Zone 5—Challacó	1940	860	12,222	535,951		28
	Province of Salta						
12	Tartagal	1926	625	5,885,044	759,963	9,403	1,246
13	Aguas Blancas	1926	45	1,070,478	65,255		
14	San Pedro	1928	455	1,265,452	626,315	11,744	988
15	Ramos	1936		5,248	17,129		
16	Río Pescado	1933	105	757,209	679,997	777	1,345
	Province of Mendoza						
17	Sosneado	1925	125	264,707	29,415		
18	Cacheuta	1932	675	462,966	39,079	67	141
19	Tupungato	1934	250	6,097,373	2,676,693	3,936	540
20	Lunlunta	1938		501,883	461,714	63	56

[b] Footnotes to column heads and explanation of symbols are given on page 264.

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wells within the proven areas, to increase production and also extend their productive limits; the deepening of existing wells and the reconditioning of old ones to maintain them at their highest output. The drilling of new wildcats was planned to determine the prospects of zones already geologically and seismographically investigated. The carrying out of this plan has been hampered by the lack of the necessary equipment and the impossibility of importing it from other countries that have all their industries engaged in the war effort.

The problem could be partly solved if at least a part of the large order for equipment placed two years ago in the United States were allowed to be exported, but only a very small quantity has been received.

Heavy drilling equipment is needed to develop the deep oil zones, the lack of casing and tubing is felt acutely and production equipment is also badly needed.

The possibility of manufacturing oil equipment in this country is being studied; in fact, plans for the manufacture of mud pumps, drill collars, slips, drag bits and miscellaneous spare parts are well underway. Pumping units built in Argentina are already working.

So far, the ingenuity of operators, the drastic measures taken regarding conservation of existing equipment and the reclaiming of old have managed to ease things and control a situation that otherwise could have become very serious.

Whether or not the efforts of those directly concerned with the matter have met with success can be judged by Argentina's oil production in 1942, which reached a total of 23,741,564 bbl., representing an increase of 1,728,092 bbl., or 7.8 per cent over the 22,013,472 bbl. obtained in the preceding year.

TABLE 1.—(*Continued*)

Line No.	Number of Oil and Gas Wells						Oil Production Methods, End of 1942		Reservoir Pressure Lb. per Sq. In.		Repressuring Operations	Character of Oil	
	Completed to End of 1941	During 1942		End of 1942			Number of Wells		Initial	Average End of 1942		Gravity, A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent
		Completed	Abandoned	Temp. Shut Down	Producing Oil	Producing Gas	Flowing	Artificial Lift					
1	2,574	72	26	166	1,677	23	8	1,685	571	71–214	SR	20	0.18
2	789	75	7	21	651	24	12	639	787	214–357	PM	23.5	0.18
3	861	62	42	106	428	30		428	286	214	SR	19	0.18
4	44			8	15	2		15				20	0.18
5	4		4	4								23	0.18
6	193	48		7	164			164	1,001	286–357	PM	23	0.18
7	67		1	17	46	2		46				32	0.20
8	183	15	4	29	144	3	32	112	887	472	SR	31.5	0.20
9	160		7	45	88	9		88			SR	33.5	0.20
10	2			2							SR	38.5	0.20
11	11	15			16		16		1,572	1,287		22.5	1.90
12	188	10		57	137		8	129	783	560	PM	43	0.10
13	6			3	26				413	316		23	0.10
14	45			19	22		14	8	726	500		46	0.10
15				1	3		3		815			53.5	
16	21	7	5	1	22		19	3	1,926	1,396	PM	49	
17	14	1		3	13			13				12.9	1.20
18	44			9	26		1	25				31	0.14
19	31	7		13	27		22	5	3,329	2,720		30	0.11
20	6	3			9		9		4,265	4,080		28	

To this increase have contributed the fields of the Comodoro Rivadavia district, in the Territory of Chubut; the fields of the Plaza Huincul district, in the Territory of Neuquen, and those of the Province of Salta.

The Government Oil Company (Y.P.F.) is largely responsible for these results, as the output of the company's wells was 15,407,154 bbl., which, compared with the 14,006,559 bbl. produced last year, represents an increase of 9.8 per cent.

Private companies produced 8,334,655 bbl., an increase of 327,743 bbl., or 4.2 per cent, over the previous year's output.

Of the total of 23,741,564 bbl. extracted from Argentina's oil fields in 1942, the Comodoro Rivadavia area contributed 16,704,236 bbl., Plaza Huincul 1,680,948 bbl., the Province of Salta 2,149,050 bbl. and the Province of Mendoza 3,347,421 barrels.

COMODORO RIVADAVIA DISTRICT

Table 2 gives the production by companies for the Comodoro Rivadavia district in the Territory of Chubut compared with that of 1941.

The increase of 987,425 bbl., or 6.2 per cent, shown for 1942 resulted from drilling new wells within the proven areas, the main factor responsible for the better output being the careful selection of the well locations so as to place them in the most favorable areas.

The Y.P.F. drilled 147 new wells in this area, which contributed 1,151,344 bbl. to the total mentioned for the district. Of these, 108 were within proven areas, 18 were extension wells, 14 were structural wells and 7 were wildcats.

Extension wells opened new areas for future development in the Manantiales Behr, El Tordillo, and El Trébol areas.

TABLE 1.—(*Continued*)

Line No.	Producing Formation								Deepest Zone Tested in 1942	
	Name	Age[e]	Character[f]	Porosity[g]	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure[h]	Name	Depth of Hole, Ft.
					Top Prod. Zone	Bottom Prod. Wells				
1	Glauconitico y Chubutiano	CreU	S	30	1,815	2,805	30	AF	Chubutiano	4,769
2	Glauconitico y Chubutiano	CreU	S	28	2,260	4,290	33	AF	Chubutiano	4,409
3	Glauconitico y Chubutiano	CreU	S	15–35	1,749	2,178	17	AF	Chubutiano	4,102
4	Glauconitico y Chubutiano	CreU	S	20–25	1,917	3,300	26	A		
5	Glauconitico y Chubutiano	CreU	S		2,310	2,640	26	AF		
6	Glauconitico y Chubutiano	CreU	S	25–30	3,878	5,960	33	AF	Chubutiano	6,904
7	Dogger	Jur	S	15–20	1,881	1,954	40	MU	Liásico	1,904
8	Dogger	Jur	S	15–20	2,303	2,363	33	MU	Liásico	3,340
9	Dogger	Jur	S	15–20	2,449	2,610	56	MU	Liásico	
10	Dogger	Jur	S	15–20	3,383	3,386	20	MU	Liásico	
11	Dogger	Jur	S	15–20	3,303	3,425	66	AF	Dogger	3,876
12	Areniscas superiores	Cre	S-LS		2,139	2,219				
13	Calcáreo y Gondwana	Per	S-LS	20–25	2,883	3,093	33	A	Gondwana	6,035
14	Areniscas super. y Gondwana	Cre Per	S	20–25	4,592	4,920	40	A	Gondwana	5,182
15	Gondwana y Devónico	Per-Dev	S	20–25	2,899	2,995	30	A	Devónico	3,920
	Devónico	Dev	S	20–25	3,105	3,514		A		
16	Terciario	Ter	S	Por	4,175	4,376	103	A	Terciario	6,006
17	Víctor	Tri	S	10–25	544	551		MI		
18	Víctor Cacheuta y Portrerillos	Tri	S	10–25	1,940	3,080	13	MUP AF	Serie Porfirítica	4,303
19	Víctor	Tri	H.S	20–25	{1,740 {5,870	1,400} 6,310}	69	A	Víctor	9,639
20	Potrerillos	Tri	S	15–20	7,721	7,892	45	A	Potrerillos	9,479

TABLE 2.—*Production in Comodoro Rivadavia District*
U. S. BARRELS

Company	1941	1942	Difference
Yacimientos Petrolíferos Fiscales....	9,137,697	9,806,594	+668,877
Cía Ferrocarrilera de Petróleo......	1,420,653	1,501,479	+ 80,826
Diadema Argentina	4,235,227	4,590,375	+355,148
Compañía Astra....	923,234	805,808	−117,426
Total...........	15,716,811	16,704,236	+987,425

Structural wells contributed valuable subsurface information that will assist in the location of future wildcat wells.

Wildcats Drilled by Y.P.F.

All of the seven wildcats drilled by Y.P.F. were abandoned, the results being as follows:

Colonia las Heras Area (Territory of Santa Cruz).—Well N-6, 28 km. west northwest of Las Heras, reached a depth of 4158 ft. in sediments of the Middle Chubutiano, but found only poor sands with small quantities of oil and gas.

Pampa del Castillo Area.—Well T-87, near the railroad station of Pampa del Castillo, was drilled to a depth 6118 ft., reaching the T-63 horizon, the lowest producing level known at that time. Several sands with oil shows were found around 5600 ft. but produced a large percentage of water after a few days, causing abandonment of the well.

Western El Tordillo Area.—Well S-171, 7 km. west of the center of the Tordillo pool, penetrated the T-63 horizon, reaching a depth of 6910 ft. without finding any shows of oil or gas.

North Escalante Area.—Well G-2, 5 km. northeast of the Escalante pool, drilled to 5465 ft., found some shows of oil and gas of little importance and was abandoned.

South El Trébol Oriental Area.—Well Q-10, 2 km. south of El Trébol Oriental pool, started as a structural well but continued as a wildcat because of its structurally high position, attained a depth of 5534 ft. It reached the T-63 horizon without finding shows of oil or gas and was abandoned.

Bella Vista Area.—Well 1801, 5 km. west of the western limit of the Campamento Central field, was drilled to 4112 ft. and was abandoned.

Drilling by Other Companies

Compañia Ferrocarrilera de Petróleo drilled 57 wells in proven areas, of which 53 were producers and the rest were abandoned. The same company drilled also several wildcats.

Well Andes 8, in the Mina Andes area, 6 km. northeast of the Astra pool, found some oil sands with small output, which did not justify casing.

In the Mina Inés area, 22 km. north northeast of the Astra pool, the same company drilled five wildcats (C-6, C-7, C-8, C-9, C-10), and another in the Mina Salamanca area (MS-1), 15 km. north northeast of the Astra pool, without results.

Astra Compañía Argentina de Petróleo drilled in proven areas 35 wells, all of which were productive. In its Mina Taylor area, eastern part of the Astra pool, the AE-499, an extension well, attained a depth of 3564 ft., finding an oil sand between 3221 and 3931 ft. that gave an initial production of 189 barrels.

PLAZA HUINCUL DISTRICT (TERRITORY OF NEUQUEN)

Oil production in the Plaza Huincul district amounted to 1,680,148 bbl. in 1942, a net increase of 608,911 bbl., or 56.8 per cent, over last year's 1,071,237.

To this total the Yacimientos Petrolíferos Fiscales contributed the larger part, its production being 1,121,432 bbl., a net increase of 571,605 bbl., or 104 per cent, over that of the preceding year.

Private companies produced 558,716 bbl. of oil, which represents an increase of

37,306 bbl., or 7.1 per cent, over the 521,410 bbl. produced in 1941.

Table 3 gives the production by companies for the Plaza Huincul district compared with that of the preceding year.

TABLE 3.—*Production in Plaza Huincul District*
U. S. BARRELS

Company	1941	1942	Difference
Yacimientos Petrolíferos Fiscales......	549,827	1,121,432	+571,605
Standard Oil Co. of Argentina.........	177,114	160,537	− 16,577
Compañía La República.............	344,296	398,139	+ 53,883
Total.............	1,071,237	1,680,148	+608,911

As mentioned, the outstanding increase registered for the Plaza Huincul district is chiefly attributable to the Government-owned areas, particularly the new Challaco field. This field was discovered by the Y.P.F. near the end of 1941 by well NA-4 and development was started at the beginning of 1942. Seven wells were drilled to extend the productive limits, of which five were successful, with an average initial production of 450 bbl. per day, and two were dry holes. Ten additional wells within the area thus proved gave an average initial output of 480 bbl. per day.

The discovery well NA-4, which produced from the first of the oil-bearing series, was deepened, finding other oil sands that increased its initial production to 1070 bbl. per day.

The total oil production of the Challacó field in 1942 was 462,533 bbl. while the rest of the Y.P.F. properties produced 658,898.

In all, the Y.P.F. drilled 36 wells in the Plaza Huincul district; 22 were within proven areas and 20 of them were productive. Of the rest, two were unsuccessful wildcats and 12 were extension wells, 5 of which were productive.

Wildcat NR-1, drilled in the Arroyito area, 23 km. east of the Challacó pool, reached a depth of 4336 ft. without finding any shows of oil or gas.

Well NK-1, a wildcat drilled in the Aquebeque area, 39 km. south southeast of Plaza Huincul, attained a depth of 4135 ft. without finding oil or gas.

The Compañía La República (a subsidiary of Standard) drilled six wells on its property west of the Octogon, all which were producers.

The Standard Oil Company of Argentina completed its well No. 107 as a dry hole, 1 km. southwest of its Dadin pool.

PROVINCE OF MENDOZA

Oil production of the fields of Mendoza in 1942 amounted to 3,208,414 bbl., a decrease of 139,007 bbl., or 4.3 per cent, compared with that of 1941.

The Y.P.F. fields contributed 3,178,199 bbl., which represent a decrease of 165,212 bbl., or 5 per cent, compared with production of the previous year. This was caused by lack of equipment, which interfered so much with oil-field activities in Argentina and especially in the Mendoza field, where the depth makes it necessary to use heavy and powerful machinery.

The only private company operating in the Province of Mendoza produced 29,415 bbl. of oil. Production from its Río Atuel property was suspended during 1941 and resumed in 1942.

Table 4 gives the production by companies for the Mendoza district compared with that of 1941.

TABLE 4.—*Production in the Province of Mendoza*
U. S. BARRELS

Company	1941	1942	Difference
Yacimientos Petrolíferos Fiscales......	3,344,211	3,178,999	−165,212
Compañía Río Atuel..	3,210	29,415	+ 26,205
Total............	3,347,421	3,208,414	−139,007

The Y.P.F. completed 12 wells. Four of these were within proven areas and four were extension wells, all productive; the other four included two deep tests in the Tupungato field and two wildcats.

In the Tupungato field the Y.P.F. drilled wells T-48 and T-50 to investigate the productivity of a deeper formation known as the Estratos de Potrerillos, which is the producing horizon of the Barrancas field. The T-48 found oil in the Víctor Gris inferior, a high formation, and was completed with an average initial production of 44 bbl. per day.

The T-50, incidentally the deepest well drilled in this country till the end of 1942 (9640 ft.), penetrated the upper part of the Estratos de Potrerillos, giving a daily average of 63 bbl. These results, although of small economic value, prove the productivity of these formations. Further drilling will allow them to be tested thoroughly.

Well PP-2, 62 km. south of Malargüe in the southern part of the Province of Mendoza, was drilled to 4345 ft., finding oil in the lower Neocomian. It gave a daily average initial production of 45 bbl. but is not being produced on account of its isolated location.

In the Huayquerías del Este area, 70 km. south of the Barrancas field, the wildcat well HE-1 was drilled to 6560 ft. and abandoned in what is believed to be the Paleozoic.

Well TR-2, which at present is Argentina's deepest well, is being drilled by the Y.P.F. in the Tupungato-Refugio area to test the productivity of the Refugio structure. It has reached a depth 10,560 ft. and drilling operations are still in progress.

PROVINCE OF SALTA

The Province of Salta produced 2,149,050 bbl. of oil, increasing by 267,837 bbl., or 12.4 per cent, the amount obtained in 1941.

Table 5 shows the amounts contributed to this total by the Y.P.F. and Standard Oil Company of Argentina.

The fields under the control of the Y.P.F. produced 32.7 per cent more oil than in 1941, owing to new wells drilled within known pools.

TABLE 5.—*Production in Province of Salta*

U. S. BARRELS

Company	1941	1942	Difference
Yacimientos Petrolíferos Fiscales	978,038	1,300,188	+322,150
Standard Oil Co. of Argentina	903,175	848,862	− 54,313
Total	1,881,213	2,149,050	+267,837

In the Tranquitas area, southern part of the Tartagal zone, Y.P.F. drilled eight wells, which reached the Gondwana oil sands within the proven area and gave an average initial daily production of 230 bbl. Five extension wells also were drilled, three reaching the Gondwana sands, of which only one was productive. The other two were drilled only to the upper oil horizon, with poor results. The average daily initial of the productive wells was 54 barrels.

In the Río Pescado field four wells were drilled to the Río Pescado horizon within the proven area, which gave an average initial production of 226 bbl. per day; also three extension wells, of which one was dry and the other two averaged 158 bbl. per day.

Well AM-3, a wildcat drilled in the Anta Muerta area 3.5 km. north of the Río Pescado field, reached a depth of 6025 ft. and was abandoned.

An important wildcat was started by the Y.P.F. on the Río Seco structure, 30 km. east northeast of the Río Pescado field. A thick sand with shows of oil was found between 4872 and 5250 ft. Casing was cemented at 5009 ft. and the part of the sand below that depth was found to contain water with only small shows of oil. The section behind the pipe will be tested after greater depths have been explored. Drilling is now in progress.

The Standard Oil Company of Argentina completed two producing wells during the year in the Lomitas pool of the Tartagal zone.

PROVINCE OF JUJUY

Ultramar S.A.P.A. started drilling operations 15 km. north of Caimancito station, Province of Jujuy in its well 26-U No. 1. This wildcat, which is now drilling below 8900 ft., will investigate the prospects of the Sausalito structure.

TERRITORY OF CHACO

The Y.P.F. commenced drilling operations 16 km. northwest of the town of Charata, at well CH-1.

Petroleum Production in Mexico during 1942

By J. M. de la Garza Cárdenas,* Member A.I.M.E.

The total production of oil in Mexico in 1942 was 34,715,547 bbl.; that is, 8,179,254 bbl. less than the amount produced in 1941. The daily average for 1942 was 95,111 bbl., while that for 1941 was 117,520 barrels.

The reduction of 22,409 bbl. per day in production was due to a decrease in exports because of the scarcity of tankers. This reduction has affected principally the Northern and Southern districts of the Tampico area; in December the Northern district (Panuco) was producing less than 2000 bbl. per day with 445 wells shut down and the Southern district (Golden Lane) less than 4000 bbl. per day with 140 wells shut down.

Drilling.—During the year 14 wells were drilled in Mexico, of which five were productive. Seven dry holes were drilled in Ebano, Tampico Northern district, in search for new producing fractures; plans are being made to explore this area by means of resistivity measurements. Three producing wells were completed in Poza Rica. Drilling in this important field will continue during 1943 to determine its extension to the west. In the Isthmus of Tehuantepec no wells were completed. Two gas wells were completed in northeastern Mexico.

Wildcats.—Two wildcat wells were completed during the year, to test the extension of the Golden Lane to the south; both were unproductive. In the Isthmus a deeper sand was found in the El Plan field. This discovery has made an important increase in the reserves in this field and will allow an increase in the production of the area during 1943. In December, three exploration wells were being drilled, two in the Tampico area and one in the Isthmus.

Operating Technology.—Satisfactory progress has been made in Mexico in the application of petroleum engineering to the development and operation of the oil fields. Mud control is now an established practice and has lessened the number of fishing jobs and has allowed more open hole to be carried than formerly was possible. During 1942 the first effective use was made of determinations of bottom-hole pressure, and other modern production practices such as gun-perforating and squeeze-cementing are being introduced.

Plans for 1943

The oil production during 1943 is expected to be slightly larger than that of 1942, especially if tankers are available for exporting crude and refined products. The Government proposes to increase exploration and drilling activities to increase the reserves and potential production of the country; about 50 wells will be drilled during the year, including wildcat wells in northeastern Mexico, Tampico and Isthmus areas and exploitation wells in the Ebano-Panuco, Poza Rica, El Plan and Cuichapa fields.

Acknowledgment

Mr. A. Barnetche, of the Production Department, "Petróleos Mexicanos," assisted the writer in the preparation of the statistical data.

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Line Number	Field	Year of Discovery	Area Proved, Acres		Total Oil Production, Bbl.		Total Gas Protion, Millions Cu. Ft.		Number of Oil and/or Gas Wells.					
										During 1942		End 1942		
			Oil	Gas	To End of 1942	During 1942	To End of 1942	During 1942	Completed to End 1942	Completed	Abandoned	Temporarily Shut Down	Producing Oil	Producing Gas
	Northeastern Mexico:													
1	La Presa	1934	0	y	0	0	2,781[2]	163[2]	3	0	0	0	0	3
2	Laredo	1937	0	70	0	0	0	0	3	0	0	0	0	3
3	Mier	1936	0	y	0	0	12,022[2]	2,190[2]	6	1	0	0	0	6
4	Rancherías	1933	0	1,230	0	0	12,837[2]	355[2]	7	1	0	0	0	7
	Tampico Area:													
5	Poza Rica	1930	12,420	0	171,106,758[1]	22,074,570[1]	187,491[1]	26,577[1]	41	3	0	11	30	0
6	Northern District (Ebano, Pánuco, etc.)	1904	100,000	0	760,356,329	3,678,164	x	x	1,651	0	0	445	282	0
7	Southern District (Golden Lane)	1908	33,000	0	1,036,233,138	3,834,663	x	x	544	0	0	140	113	0
8	Other Fields (San Sebastian, Tanhuijo, Mecatepec, Furbero, etc.)				4,039,416	14,816	x	x	55	0	0	4	3	0
	Isthmus of Tehuantepec Area:													
9	Cuichapa	1934	300	0	438,618	359,252	6,343	1,729	5	0	0	1	4	0
10	El Burro	1930	370	0	13,825,432	632,593	113,752[4]	2,502	41	0	0	7	29	0
11	El Plan	1931	830	0	44,248,889	2,501,310	303,524[4]	16,591	74	0	0	28	44	0
12	El Plan, Eastern Extension	1934	80	0	529,175	142,574	17,660	966	2	0	0	0	1	0
13	Filisola	1921	460	0	19,515,268	347,753	65,129[4]	1,159	81	0	0	0	49	0
14	Teapa Nuevo	1928	40	0	127,199	64,963	y	y	8	0	0	0	8	0
15	Tonalá	1928	470	0	40,916,804	1,064,884	308,729[4]	7,127	93	0	0	10	76	0
16	Other fields (San Cristobal, Capoacan Soledad, Concepción, Tecuanapa, Ixhuatlán, Selem, Sarlat, etc.)				y 2,091,337,026	15 34,715,557	y 1,030,268	y 59,359						

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[1] Includes one well completed in Tertiary sand with 86,639 bbl. of oil and 31 million cu. ft. of gas total production.
[2] Production for December 1942 is estimated.
[3] Includes wells temporarily shut down.
[4] Production prior to 1932 is estimated.

Line Number	Oil Production Methods, End of 1942[3]			Reservoir Pressure, Lb. per Sq. In.		Character of Oil		Producing Formation								Deepest Zone Tested to End of 1942	
	Number of Wells							Name	Age	Character[f]	Porosity	Depth, Avg. Ft.		Net Thickness, Avg. Ft.	Structure	Name	Depth of Hole, Ft.
	Flowing	Pumping	Gas Lift	Initial	Average at End of 1942	Gravity A.P.I. at 60°F., Weighted Average	Sulphur, Per Cent					Top Prod. Zone	Bottoms Prod. Wells				
1	3	0	0	*y*	*y*			*y*	Eoc	S	Por	1,925	3,160	38	A	*y*	5,960
2	3	0	0	320	320			Mount Selman	Eoc	S	20	720	732	12	Af	Carrizo	2,000
3	6	0	0	*y*	*y*			*y*	Eoc	S	Por	2,120	2,345	*y*	N	*y*	2,935
4	7	0	0	860[5]	*y*			Fayette Yegua Cook Mountain	Eoc	S	27	264	2,440	310	A	Mt. Selman	6,280
5	41	0	0	*x*	2,750	30	1.80	Tamabra	CreL	L	Por	7,250	7,546	296	N	Tri	8,499
6	727	0	0	*x*	*x*	12	3.02	Tamaulipas	CreL	L	Fis	1,148	1,968	*x*[6]	AF	Tri	4,182
7	253	0	0	*x*	*x*	20	3.64	El Abra	CreL	L	Cav	2,200	2,202	*x*[7]	AF	CreL	10,585
8	7	0	0														
9	5	0	0	*x*	650	30	1.6	Concepción Inferior	Mio	S	Por	2,100	2,133	33	DF	*y*	4,156
10	0	0	36	*x*	*x*	26	1.5	Concepción Inferior Encanto	Mio	S	Por	2,460	2,620	62	Ds	Olig	5,423
11	7	8	57	*x*	*x*	24	2.00	Cedral Lignítico	Mio	S	Por	1,970	2,440	216	Af	Mio	6,191
12	0	0	1	*x*	*x*	35	1.45	Concepción Superior Concepción Inferior Encanto	Mio	S	Por	3,883	4,110	32	NF	Mio	5,327
13	0	49	0	*x*	*x*	22	3.42	Encanto	Mio	S	Por	1,585	1,980	92	TF	Mio	3,608
14	0	8	0	*x*	*x*	36	1.15	Encanto	Mio	S	Por	429	711	29	Ds	Mio	1,733
15	1	68	7	*x*	*x*	28	1.60	Concepción Superior Encanto Depósito	Mio Mio Olig	S	Por	1,640	2,130	167	Ds	Eoc	4,287
16																	

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[5] Refers to deepest sand.
[6] Production found in fractures at any level within depths indicated.
[7] Reef-phase limestone penetrated only 2 feet.

Chapter VI. Refining

Review of Refinery Engineering for 1942

By Walter Miller,* Member A.I.M.E.

After a year's continued impact of war, the task of the petroleum-refining industry stands out clearly and looms up in larger aspect. This time it is not, as it was so largely in the first World War, simply a matter of increased quantity—more and more of the same petroleum products that had substantially been standard for years. In this era the emphasis is largely on newer and improved materials which had been produced, if at all, in comparatively insignificant quantities, and for which manufacturing equipment was not available on a large scale. At the beginning of 1942 four great product needs (besides a number of lesser ones) confronted the industry: 100-octane aviation gasoline, toluene for T.N.T. production, high-quality lubricating oils for aviation and Army equipment service, and petroleum chemicals for synthetic rubber manufacture.

The difficulty in presenting a review of engineering progress in petroleum refining during 1942 is that there is so little one is free to say about so much which has been and is being accomplished.

At the opening of 1942 the program was to increase the then existing capacity of 50,000 bbl. a day of aviation gasoline to over 150,000 bbl. daily by building new plants at an estimated installation cost of $150,000,000. Later in the year, after the announcement by President Roosevelt of a large increase in the program for war-plane building, additional contracts were made between the Reconstruction Finance Corporation and refiners to raise the capacity to 250,000 bbl. per day. The greatly increased scope of the war activities in all parts of the world, the obligation of the United States as the arsenal of the United Nations, and the greater importance and use of bomber, transport, and cargo planes will undoubtedly bring about plans and installations for a further increase in production of aviation gasoline over the present announced plan.

In this connection, Jesse Jones, Reconstruction Finance Corporation Chairman, announced that as of Oct. 31 the R.F.C. had through its subsidiary Defense Plant Corporation entered into contracts for the construction, expansion, or equipping of 28 plants to increase 100-octane aviation gasoline production, but gave no data on capacity involved or completion dates. His list did not, of course, include a number of existing plants, and some installations being made by companies who are themselves financing the construction.

Production from existing operating installations was materially increased in a number of instances as a result of pooling knowledge of improvements in operation and also by the exchange of components going into 100-octane blend to enable greater quantities of aviation gasoline to be produced from the over-

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all component materials available. Progress has also been made in know-how and practice for improved quality in the form of rich-mixture characteristics for better performance in starting and emergency full-throttle power output and in flying under supercharging conditions.

Some new installations of toluene-producing plants with comparatively small capacities came into operation during 1942. Several contracts were entered into for hydroformer and solvent extraction units, the latter for refining the toluene produced by such hydroforming operations. These new installations are to be completely ready for operation during 1943.

Current production of toluene during the year was considerably augmented by the ability of the Baytown Ordnance Works to refine more toluene than was produced in its hydroformer operation. As a result of this fortunate condition the Continental Oil Co., the Pan American Refining Co., Sinclair Refining Co., and the Shell Oil Co., pending the completion and operation some time in 1943 of their toluene extraction and refining facilities, were able to ship to the Baytown Works distilled concentrates containing from 25 to 40 per cent toluene, which the Ordnance Works finished up and made available immediately for nitration to T.N.T. Several million extra gallons were "prematurely" made available by following this procedure, a worth-while contribution, as it made possible the additional production of more than 14,000,000 lb. of T.N.T. for every million gallons of toluene so made available.

During the year a series of technical meetings was held under the auspices of the Ordnance Department, working with the Petroleum Administration for War. These meetings were attended by all immediately interested process and plant designing and construction companies, by catalyst developing and manufacturing companies, and all refining companies making toluene or about to make toluene. All experience and know-how pertaining to processes, design, and operation of both hydroformer and toluene extraction and refining units, including catalyst manufacture, composition and use, were freely discussed and exchanged. Chemicals, analytical knowledge, and experience, important both as to charge stocks and intermediate and finished products, were also brought out in these discussions, so as to bring about the universal adoption of accepted best methods of examination and analyses. These meetings, one illustration of the working out of a general program in the industry for co-operative research and development in petroleum refining in connection with production of essential war products, have been productive in many ways, and the current toluene output with the facilities at hand has been considerably enhanced. The good results of better feed-stock selection and preparation, better catalysts and use technique, improved operations of hydroformers and toluene-refining facilities are all apparent and are of course available also for new installations as they come "on the line."

Though detailed figures on production are not available, the program is proceeding somewhat better than expected. The rate of use of T.N.T., however, also seems to be going beyond previous estimates, and every effort will be needed to meet requirements.

No further installations for solvent-treating plants to increase production of high-grade lubricating oil were announced as having been authorized during the year. The new plants authorized in 1941 and mentioned in my review for that year must be close to completion if not already in operation. The requirements during the year were met without difficulty by existing installations, but the output of the new plants will be needed to help take care of the widely extended requirements as our activities and those of our allies in this global war approach their zenith. It is understood that the situation is being closely studied from the viewpoint of anticipating possible additional capacity requirements.

In late 1941 and early 1942 it was evident that because of loss of supplies of raw rubber from the Netherlands Indies and the Malay peninsula all previous plans and figures pertaining to the making of synthetic rubber were woefully inadequate.

A scrutiny of possible sources of raw material and methods of manufacture was instituted by governmental agencies having responsibility and authority in the situation, in combination with a number of the larger oil and rubber companies which, because of previous efforts and study and potentialities for producing large quantities, were already, so to speak, in the field. Early 1942 estimates of the needed quantity of synthetic rubber, amounting to something on the order of 750,000 long tons per year, since then raised to 1,100,000 long tons as the effect of global warfare and our obligations were given more weight in the estimates, may be compared with the small-scale plan looking to 120,000 long tons of synthetic rubber production a year which was still extant toward the close of 1941.

The general synthetic rubber situation was confused because of the fact that three or four governmental agencies were involved and because of differing opinions as to whether the raw material for the bulk of the program which had to be entered into should be obtained from the petroleum industry or from alcohol, the latter largely to be made from farm products. These differences of opinion and overlapping authority and responsibility caused some delay in going ahead with the broad-scale program. However, considerable, if somewhat halting and controversial, progress was made in the way of entering into contracts for projected plants for the manufacture of butadiene and other chemicals required, and for facilities for converting these chemicals into synthetic rubber, before the confusion became so serious that public opinion demanded it be straightened out.

In July the President appointed a special committee, popularly known as the Baruch Committee, to make a study immediately of the entire synthetic rubber situation, with instructions to report their findings to him with recommendations as to the best course to be pursued. The Committee consisted of Bernard M. Baruch, who was head of the War Industries Board of the first World War; J. B. Conant, president of Harvard University; and Karl T. Compton, president of Massachusetts Institute of Technology, aided by a staff of about 25 able experts. This Committee's report was completed in a gratifyingly short time, was generally accepted as comprehensive and adequate and as a clear statement of the rubber problem, and was promptly approved by President Roosevelt. Among the recommendations made was that all authority and responsibility for the program recommended by the Committee be vested by a Presidential directive in the War Production Board, and that a rubber director be appointed by Chairman Nelson of W.P.B. with full and complete authority and responsibility to carry out the program for W.P.B. Rubber Director Jeffers took charge in September. As a measure of what had been done up to that time, Chairman Jones, of the R.F.C., reported later in the year that by Oct. 31, 1942, the Defense Plant Corporation had contracted for the construction of 67 plants at an estimated cost of $546,000,000 for the manufacture of chemicals and other components for, and conversion of them into, synthetic rubber. This report stated that these plants provided the chemicals and facilities for making 947,000 long tons of synthetic rubber annually.

Some additional projects were approved by Mr. Jeffers by the end of the year looking to the fulfilment of the program for 1,100,000 long tons recommended by the Baruch Committee, according to statements made by Deputy Rubber Director Dewey in testifying before the Rubber Investigating Committee, chairmanned by Senator Gillette. Mr. Dewey mentioned three additional Houdry butadiene units and some refinery conversion products approved and under consideration.

In a strong and able report dated Nov. 30, Mr. Jeffers expressed the fear that because of possible conflict with other governmental agencies in competition for the critical materials needed for the completion of the necessary plants, important time would be lost, and warned that even a month's delay might have a serious effect during late 1943 on the rubber situation. Discussions of relative priority rights for critical construction materials as between the 100-octane gasoline and synthetic rubber programs have been held and a new plan for allocation and delivery date-freezing of necessary construction materials has been worked out under a system of "Urgency Numbers." This, it is hoped, will assure the delivery of materials at the right time at the construction sites, and avoid the delays feared by Mr. Jeffers.

The refining industry continued rapidly to expand its research and development activities in the newer fields of plastics and chemical manufacture, as well as war products. A start has been made in giving effective aid to Russia in the fact that the refinery recently built by the Douglas Oil and Refining Co. on the Pacific seaboard is to be transported bodily to Russia. This is reported to be the first step in a program involving some $15,000,000 to $20,000,000. The industry has given the services of many of its outstanding executives and technical men to assist Petroleum Administration for War and other governmental agencies in various phases of the prosecution of the war. It is making adjustments by lengthening working hours and training women for suitable jobs to offset the loss of man power to the armed forces and to care for its own plant expansion.

During the past year the industry met substantially all the demands that were made upon it for the prosecution of the war. It has expanded and is expanding to handle satisfactorily the much larger calls that will be made upon it during the coming year.

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